

TN  
57  
L84+  
v.1  
pt.3



**Cornell University Library**

BOUGHT WITH THE INCOME  
FROM THE

SAGE ENDOWMENT FUND  
THE GIFT OF

**Henry W. Sage**  
1891

A.800686..... 91 VIII 15.  
3777

ENGINEERING LIBRARY

Cornell University Library  
TN 57.L84  
v.1, pt.3  
Records of the School of Mines and of sc  
  
3 1924 004 682 252  
engr



# Cornell University Library

The original of this book is in  
the Cornell University Library.

There are no known copyright restrictions in  
the United States on the use of the text.

MUSEUM OF PRACTICAL GEOLOGY  
AND GEOLOGICAL SURVEY.

---

RECORDS  
OF THE  
SCHOOL OF MINES  
AND OF  
SCIENCE APPLIED TO THE ARTS.

---

VOL. I. PART III.

ON THE MINES OF WICKLOW AND WEXFORD.

BY

WARINGTON W. SMYTH, M.A., CAMB.,  
MINING GEOLOGIST TO THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

---

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF  
HER MAJESTY'S TREASURY.

LONDON:

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE.

PUBLISHED BY

LONGMAN, BROWN, GREEN, AND LONGMANS.

1853.







MUSEUM OF PRACTICAL GEOLOGY  
AND GEOLOGICAL SURVEY.

---

RECORDS

OF THE

*Royal*  
SCHOOL OF MINES

AND OF

SCIENCE APPLIED TO THE ARTS.

---

VOL. I. PART III.

ON THE MINES OF WICKLOW AND WEXFORD.

BY

WARINGTON W. SMYTH, M.A., CAMB.,

MINING GEOLOGIST TO THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

---

PUBLISHED BY ORDER OF THE LORDS COMMISSIONERS OF  
HER MAJESTY'S TREASURY.

LONDON:

PRINTED FOR HER MAJESTY'S STATIONERY OFFICE.

PUBLISHED BY

LONGMAN, BROWN, GREEN, AND LONGMANS.

---

1853.

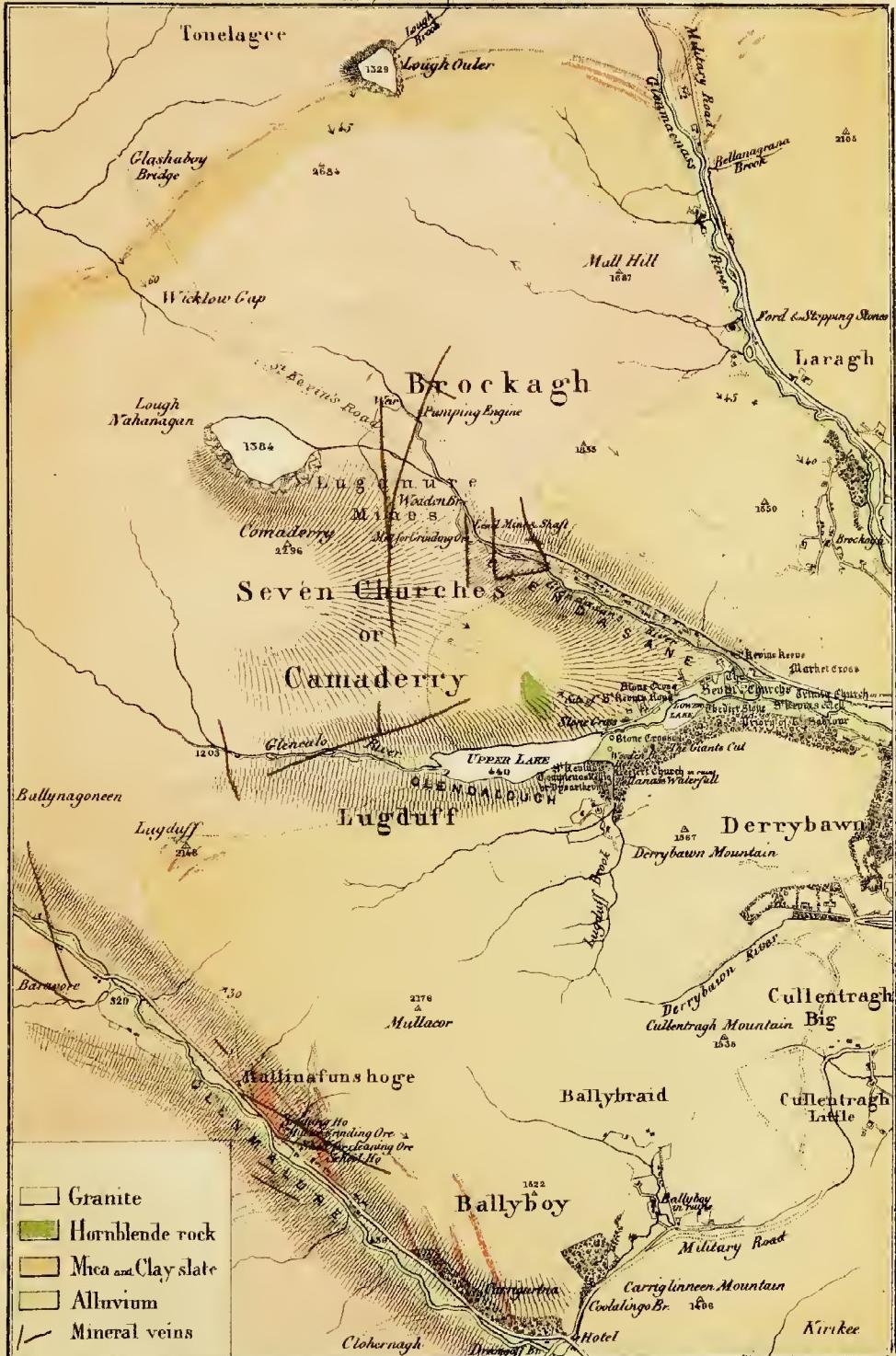
E.V.

(w)

LONDON : PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,  
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

# MAP OF THE MINING DISTRICT OF LUGANURE GLENDALOUGH AND GLENMALURE

Scale, one Inch to one Mile



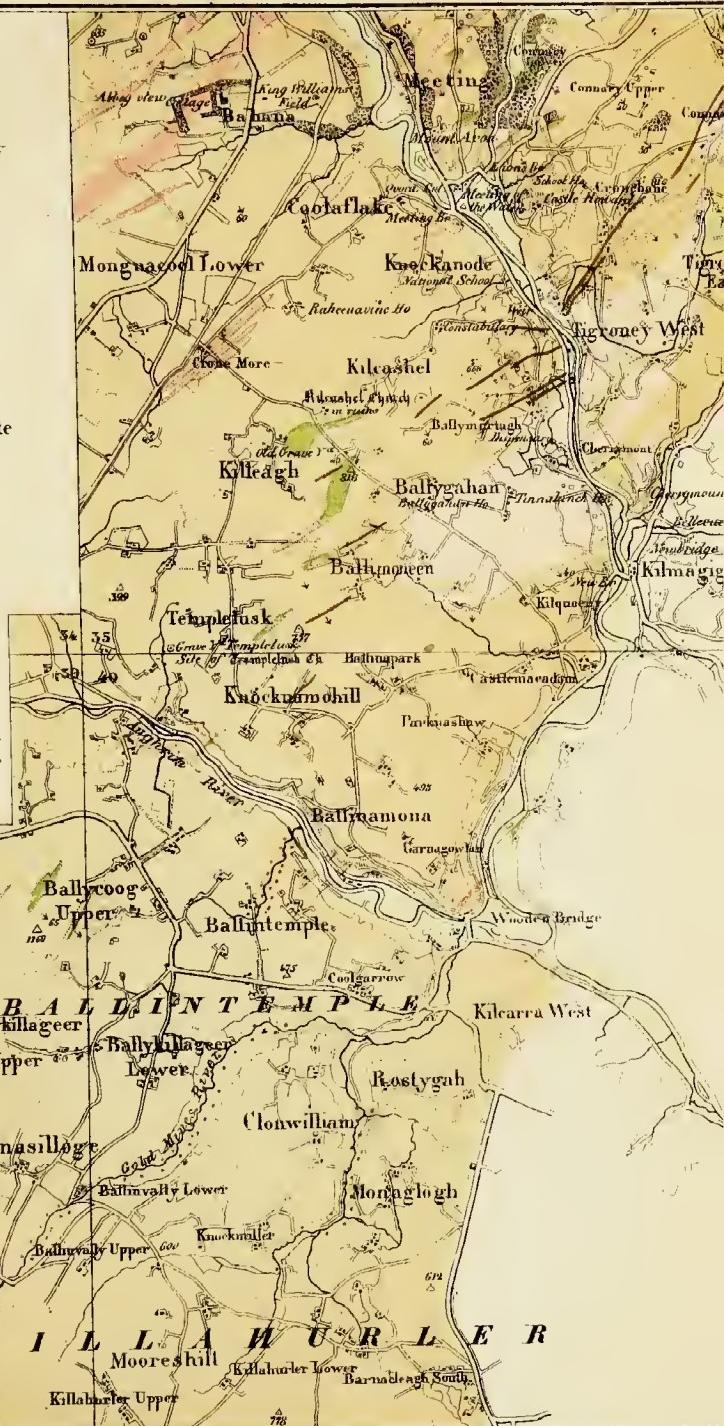


**MAP OF THE MINING DISTRICT**  
extending  
**FROM CROCHAN KINNELA TO CONNARY**  
*Scale one Inch to one Mile*

## REFERENCES.

- |  |                                    |
|--|------------------------------------|
|  | Granite and<br>granitic porphyry   |
|  | Felsite or<br>Silicious Felspar    |
|  | Greenstone and<br>hornblende slate |
|  | Argillaceous slate                 |
|  | Alluvium                           |
|  | Mineral veins                      |

The large numbers 34, 35,  
39, &c, refer to the sheets of  
the Ordnance Map





Ballymurtagh

Tigroney

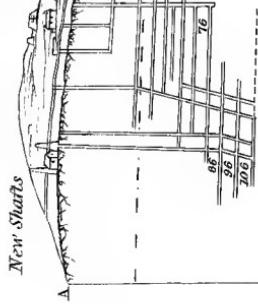
Cronebane

N

C

D

B



New Shafts

E

Mossy Shafts

Boundary Shaft

Farmers Shaft

Sea Level

10  
20  
30  
40

### DIAGRAM

illustrating the  
DISLOCATION OF THE LODES OF THE  
OYOGA MINES.

Scale, 6 Inches to One Mile





*On the Mines of Wicklow and Wexford.*

By WARINGTON W. SMYTH, M.A. Camb.,

MINING GEOLOGIST TO THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM.

THE county of Wicklow has long enjoyed a celebrity due no less to its mines and minerals than to the natural beauties which adorn its landscapes : the copper ores of the Vale of Ovoca attracted attention at a very early period, and the gold which was discovered towards the close of the last century, excited great interest among all classes on both sides of the Channel. At the present day the mineral produce of the county may in some respects be less abundant than heretofore, but in others it has been much increased ; and independently of the intrinsic value of the substances thus realized, the constant employment of a very large number of the working classes invests the subject with great importance.

The mines of Wicklow and the adjacent counties were very fully described by Mr. Weaver in his excellent Memoir on the Geological Relations of the East of Ireland, read before the Geological Society of London, in May 1818. Many of the features of Geological Science have been modified since that time, and its economic applications have passed through various phases, which render it desirable to offer a view of the present condition of the district ; yet Mr. Weaver's paper remains an instructive example of the advantages to be derived from the publication at various intervals of detailed descriptions of mining localities, advantages which must be appreciated by all those who are personally interested in mining operations, and cannot but be valuable to the higher aims of science pursued for its own sake.

The natural division of the county of Wicklow into two parts,—an elevated mountain tract of granite on the west, and a region mostly composed of clay-slate on the east,—coupled with the distinct character of the metalliferous deposits respectively occurring in these portions, lead to the consideration of our subject under the following heads, 1st, the lodes or mineral veins in the granite ; 2dly, the ore deposits in the clay-slate ; and

3dly, the gold and other minerals which have been met with in the drift or superficial detritus.

The boundary line between the granitic and slate regions runs from N.N.E. to S.S.W.; and within a small width along its western side veins of lead ore have been discovered at intervals, for a distance of about 30 miles, if we include also a few miles which lie within the county of Dublin. The generally received view of the eruptive origin of this granite, and the effect which its original high temperature has produced on the clay-slate in contact with it, will be discussed elsewhere; and it is only necessary to observe, that although the modifying action has been so intense that a band of these slates for about half a mile in width, all along the edge of the granite, has been metamorphosed into mica slate, and the crystallisation of numerous anhydrous silicates has been developed, there is no ascertained instance of a metalliferous vein occurring altogether within the limits of the slate near this junction; and in almost every case where a few have been traced towards the overlying beds of that rock, they disappear as they approach it.

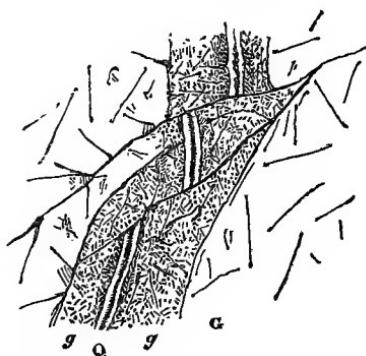
The granite of this district is generally of a grey tint and coarse structure; of its component parts the quartz is colourless, the felspar nearly always white, and the mica very commonly black. Accidental minerals rarely enter into its constitution, but it is to be observed, as a point of some importance, that in the neighbourhood of the metalliferous veins, a green steatitic mineral in small irregular flakes and lumps occurs abundantly, and not unfrequently occasions a softness and tendency to disintegration through the whole mass. In some portions of the tract large crystals of felspar make their appearance, rendering the granite porphyritic, and lending it very much the aspect of the granites of Cornwall.

The surface of the mountainous region is so covered with bog that the fundamental rock can rarely be seen, except in the brook courses and on the hill-tops, where the vegetable covering has been swept away by the rains. It may possibly be a result of this concealment of all the central granite, that lodes have seldom been observed at a greater distance than a mile and a half from the edge of the slate rocks, near which line of boundary most of the denuded places are situated. At such spots, however, it is remarkable that the principal mass is seamed by a

vast number of veins of a granitic character, some of a finer others of a coarser grain than the adjacent rock, and in their origin partly contemporaneous with its solidification and partly of a more recent date. These veins frequently contain other minerals, as steatite, garnets crystallized as well in the icositetrahedron as in the rhombic dodecahedron, sparry iron, and, more rarely, beryl; and from their intimate relation to the mineral veins deserve a close attention.

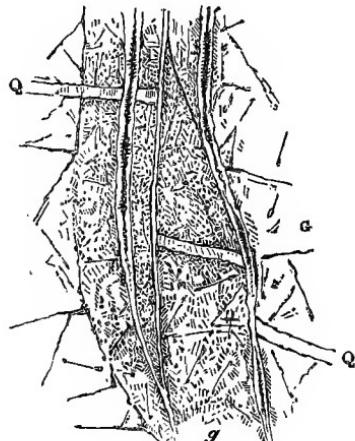
The granitic veins, varying from an inch to several feet in width, are not very uniform in their direction, but exhibit a general tendency to follow very nearly the meridian line, a course analogous to that of the prevailing joints of the great rock masses. A riband of quartz frequently accompanies them, sometimes at the side, and sometimes in the middle of the vein, and evidently formed by simultaneous action on both sides of a narrow crack, which, when rather wider than usual, has allowed the development of quartz crystals with their points facing each other. Dislocations of some of the veins may be observed, but the contradictory phenomena offered by them would appear to indicate that at the time of the deposition of the longitudinal quartz strings, the granite of the veins must have been in a yielding condition. Thus in Fig. 1. of the accompanying examples, taken from Glendalough, the quartz-thread has been twice shifted by cross fissures, which have not altered the position of the granite vein. In Fig. 2. a vein of compact quartz has cut through both the varieties of granite, and has itself been divided and shifted by the narrow threads of crystallized quartz.

Fig. 1.



*G* Granite.  
*g* vein-granite, often containing steatite.  
*Q* Quartz veins.

Fig. 2.



In almost every instance which has fallen under my notice, each metalliferous vein consists, on the hanging or upper side, of a rib of granitic material,—a true granite vein indeed, generally coarse-grained and white, but sometimes assuming a beautiful pink tint from the predominance of felspar of that colour. Mica, often in large laminæ, is an abundant ingredient, and is commonly the white species known as potash mica, whilst that of the adjacent granite is often the black or soda mica in more distinct crystalline plates.

To whatever origin we may refer the great mass of enveloping granite, it is difficult to assign to these veins any other mode of formation than that to which we may ascribe the deposition of the various substances which occur in the mineral lodes, with which the granite veins are so closely associated. The minerals most frequently appearing in the lodes are galena, zincblende, carbonate of iron, copper pyrites, quartz, barytes, and calcareous spar, all of which, we have reason to believe, have been deposited from solution; and in extending this view to the granite veins, the felspar and mica alone present the difficulty of not occurring mingled with the ore-bearing parts of the lode. The first impression produced on the observer at many localities by the friable character of the granite veins is, that they have been mechanically made up from the detritus of the adjoining granite; but an examination of other spots will, I think, lead to the conviction that the constituent parts have been chemically placed where we now find them.

The felspar and mica are sometimes found in crystalline forms, the development of which has not been impeded by the quartz, a fact, however, not more remarkable in these veins than in granite rocks generally. The position of the granitic veins on the hanging side of the entire fissure, (as represented in several of the following diagrams,) seems to show that they fill a part of the lode which was rent open after the consolidation of the minerals on the lower or "foot-wall" side; and I shall have to point out one instance in which I observed a vein cutting obliquely through all the rest, filled almost solely with white mica, and which being but from 1 to 3 inches in width, can have been filled with that mineral only by crystallization from a watery solution.\*

---

\* The most satisfactory proof that mica frequently crystallizes from watery solutions is obtained from the fact, that it often occupies the shape

*Mines of the Granite District.*—The most important groups of lodes, or mineral veins, occur in Glendasane and Glenmalure, two valleys which open in straight lines with a N.W. and S.E. course, or nearly perpendicular to the general strike of the mountain range, and, from their bold and abrupt character, form a very remarkable physical feature of the country. In Glendasane several mines have been opened, one of which, the old Luganure mine, was worked in the early part of this century, under the direction of Mr. Weaver; and has, after lying dormant for many years, been lately re-opened, whilst others have been commenced and kept in operation by the Mining Company of Ireland. In Glenmalure, one mine only, which has for a long period been alternately opened and abandoned, is successfully conducted by Mr. Hodgson of Ballyraine, although other adventures have from time to time been set on foot, under occasional appearances of promise.

Above the waterfall in Glendasane, several almost parallel lodes, in a width of 5,000 feet, course within a few degrees of N. and S., and have been explored under the general name of the Luganure mines.

The most easterly of this number, called the *Fox Rock* vein, is only 400 or 500 feet from the edge of the mica-slate, but although opened by five levels on the side of Brockagh mountain, and producing fine lumps of galena, it has not invited extended operations.

The *Moll Doyle* lode, dipping at the unusually low angle of  $45^{\circ}$  to the west, was accidentally discovered in the bed of the brook a few years since, and has been worked irregularly for lead-ores to a depth of 40 fathoms, and under a length of about 50. Nearly half way between the two small shafts, the vein appears to be dislocated, but no continuous levels have been carried from one to the other.

At 150 fathoms farther to the west, the *Hero* lode, striking N.  $5^{\circ}$  E. and dipping  $60^{\circ}$  to  $80^{\circ}$  west, has been proved with regularity to 80 fathoms in depth, and for about 120 in length.

---

of some other mineral whose constituents have been carried off after decomposition, by water, carbonic acid, &c. Mica thus replaces the substance of Felspar, Tourmaline, Wernerite, Pinite, Andalusite, and several others. Vide Blum's *Pseudomorphosen des Mineralreichs*, and Bischof's *Lehrbuch der chemischen und physikalischen Geologie*, vol. ii. p. 1426.

Its average width is 5 feet, but the galena is very irregularly disposed throughout a vein stuff of fragmentary and apparently triturated granite, which is seamed by more or less abundant portions of quartz, associated with zinc blende and calcareous spar in three varieties, one of which is massive, and of a pink colour ; the second occurs in transparent tabular crystals, and the third in the tender foliaceous form denominated *schiefer*—or *slaty spar*, of a greenish white colour, and saponaceous to the touch. The lead ore was found principally in two accumulations or “bunches,” one of which near the Bog shaft, accompanied the junction of two portions or branches of the lode, and does not appear to have been reached at the 80 fathom level, where the underlie, or inclination of the vein, would throw it 20 fathoms south of the shaft. The north and south continuations of the lode have been proved ; in the first case only about 50 fathoms from the shaft ; in the second not more than a few feet from the engine shaft.

The *Ruplagh* lode, striking N.N.E., with a westerly underlie, has been explored in three separate mines, the *Hawk Rock*, *Ruplagh*, and *North* mine, of which only the latter is now open ; it may be traced for a mile in length, of which some 600 fathoms have been “proved” by mining operations. The Ruplagh mine was sunk by two engine shafts to the depth of 100 and 110 fathoms, and a large quantity of ore was extracted from it ; at the south end of the 110-fathom level, a “feeder” of warm water, often considered a precursor of ore, was cut shortly before the catastrophe which occasioned the abandonment of the mine. In 1844, the dry summer so reduced the water of Lough Na-hanagan, which supplies the motive power to the machinery, that the pumps could not be kept in action, and the excavations were drowned ; whilst it is inferred from the destructible nature of the granite, that all is now in so ruinous a state, as to be dangerous to re-open.

In the North mine a shaft has been sunk on a “bunch” of ore, to a depth of 105 fathoms, at which level the favourable appearances which had excited hopes at 90 fathoms deep dwindled away again, whilst all the levels, or horizontal galleries driven into the body of the granite on the northward, some of them to a very great distance (as the 70-fathom level above 150 fathoms in length), passed along a vein almost entirely destitute

of ore. At the adit level the lode is cut through and very slightly dislocated by a cross vein which courses N.W. by W.

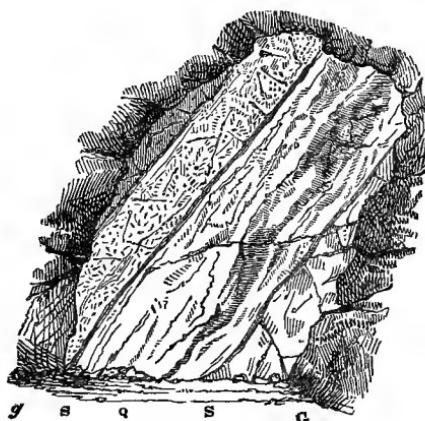
The Hawk Rock, or North Laganure mine, has been opened to a considerable length at the 16 and 26 fathom levels, but to a very small extent at greater depths, where the diminution of the lode to 6 inches wide at 66 fathoms deep, occasioned such disappointment that the mine has, since 1846, been abandoned, like its neighbour the old Ruplagh mine, to the waters.

The average width of the Ruplagh lode is 3 feet, and although it seldom exhibits a regularly banded structure, it is always accompanied by a vein of soft granite varying from an inch to 2 feet in size, which is often bounded on both sides by a "sticking," or thin layer of clay, the "besteg" of German miners. The galena occurs always in "bunches" of small extent, and is associated with quartz, a little zinc blende, and calcareous spar, crystallized in the "vugs," or cavities which have been left in the quartz. White and green lead ore occur near the surface, and may be found on the heaps of mine refuse.

The east and west walls of the lode, which are generally well defined, show but little of that decomposition which often accompanies mineral veins, and both consist of the same kind of granite.

The following is its appearance in the north end of the 56-fathom level :—

Fig. 3.



*G* Large grained white granite.

*g* Very soft pink granite.

*Q* Quartz, fragments of granite, and galena.

*s s* "Sticking" of tenacious clay.

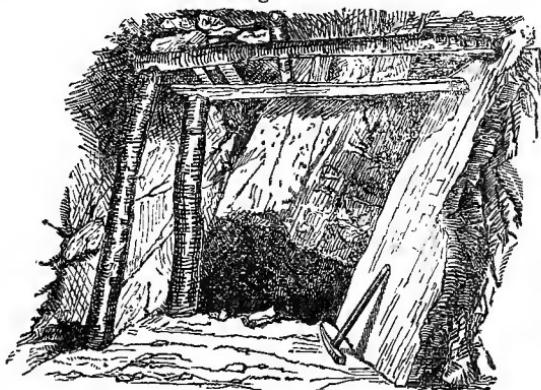
The water was extracted from both mines by a water-wheel of 24 feet diameter, and 4 feet breast, acting by flat rods from the middle of the valley to the two shafts; and a second wheel of the same diameter and 3 feet breast, effects the raising of the minerals. The neighbouring Lough Nahanagan affords a plentiful supply of water, except in unusually dry seasons, although, by suitable arrangements, it might even at such times be rendered available. On the side of Comaderry mountain, where it has not yet been worked, this lode intersects another called the Lughanure, whose course is a few degrees west of north, and has been traced from St. Kevin's road on the north, to the top of Comaderry on the south. A good deal of ore was extracted hence in the early part of this century, some of the bunches being rich enough to produce 3 or 4 tons of ore to the fathom. Several levels of great length have been driven upon it, the latest of which, under the Mining Company of Ireland, was commenced some 2 fathoms beneath the deepest of Mr. Weaver's, but was attended in the first instance with so little success, that the mine had, at the first visit of the survey, in 1846-7, been for some time abandoned.

The only work of preparation for the ultimate trial of the Lughanure lode, was an adit level called Richards's, 50 fathoms deeper than that above mentioned, which was continued southwards on the course of the Hawk Rock, or Ruplagh lode, and has now penetrated 275 fathoms into the heart of the mountain, with indifferent success as regards metallic produce, and under the disadvantage of the granite having greatly increased in hardness. Quite otherwise was it with the resumption some four years ago of the "old mine," when in the "deep adit" but two fathoms had to be driven before a fine rib of galena appeared, and now that the same level is advanced 400 fathoms from the daylight, and that the ground has been laid open upwards from hence to Weaver's and then again to the Shallow level, a height of 52 fathoms, a most satisfactory proportion of ore lode has been displayed, which, whilst narrowing above, widens out in descending, so rapidly as to give good promise of what may be expected when the deeper level arrives under the same spot.

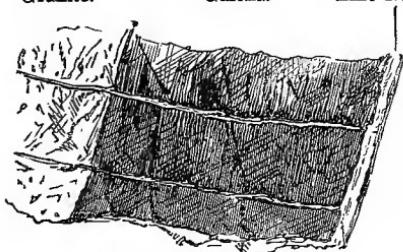
The general character of this vein closely resembles the Ruplagh: in a width averaging 4 feet, half or two-thirds consists of soft granite, whilst the smaller proportion, which is commonly

attached to the "foot-wall," or lower side, is composed of ribs of quartz, with zinc blende, galena, and occasionally barytes, and calcareous spar. Subsequently to the consolidation of the mass of the vein, it has been subjected to a force which has rent it again cross-wise, and the small cracks thus formed, from 2 to 6 tenths of an inch wide, and intersecting equally the vein-stone and the lead ore, have been filled (sometimes only partially) with blende. Figure 4. represents the typical appearance of this lode; and fig. 4 *a.* the rib of galena and zinc blende on a larger scale.

Fig. 4.

Fig. 4 *a.*

Granite.                    Galena.                    Zinc blende.



The vein granite is in part so friable that it fills the workings with a heavy sand, and it is commonly so seamed through with slip-faces, or surfaces of friction, smooth and treacherous, from the suddenness with which large masses may unexpectedly fall, that several accidents have occurred from this cause, and would be more frequent but for the speedy opening and re-closing of each "tribute pitch," or working place, brought into action.

During the last five years roads have been constructed up the mountain, railways carried underground, by which a mule

can convey three waggons at a time, a stamps of 16 heads has been erected, and the whole brought into so flourishing a state that about 200 people are now employed under and above ground. The average monthly yield is 120 tons of lead ore, producing 74 to 75 per cent. of lead, and a proportion of silver, varying from 6 to 8 ounces in the ton of lead.

A cross lode coursing nearly east and west, and exposed in the rocks on the south of the waterfall, bears traces of galena and copper pyrites, with a little blende; and induced the commencement of an adit level, which it was once proposed to carry onward for the purpose of intersecting all the above mentioned veins. A plan of this kind, which must have been adopted in any district accustomed to mining on a large scale, was not only likely to discover other lodes intermediate between those already known, but would have reached them all at such depths as to render their unwatering comparatively easy, and to obviate the expense of establishing four engine shafts within the small horizontal range of 260 fathoms, a mode of working so costly as in great part to have swallowed up the proceeds of the lead ore which was extracted during the prosecution of the Ruplagh mines.

In the granite precipices which hem in the upper end of the romantic valley of Glendalough, a powerful vein courses E.N.E. and W.S.W., advancing on the one side towards the mica slate at the boundary of which it appears to terminate, and disappearing on the other side above the waterfall of the Glenealo river. At the latter place it consists of a dyke of soft granite, accompanied by quartz, and by sparry iron ore or carbonate of iron to the width of 8 feet, spotted occasionally with copper pyrites. This ore, used with great advantage in some of the southern countries of Europe for the production of excellent descriptions of iron, would here, from the remoteness of smelting furnaces, not be worth extracting; if, however, some convenient and economical mode of pressure should render available the large tracts of peat bog which extend without interruption for many miles on the west, the sparry ironstone smelted by that fuel would yield an iron of superior quality; and it would only remain to be proved whether the ore be present in sufficient quantity to warrant the commencement of operations—a point which seems to me, notwithstanding the

appearances at the surface, to be rendered very doubtful by the changeful character of the vein.

Among the cliffs on the side of Comaderry mountain the quartz greatly predominates, and in some places, with a width of above 5 fathoms, rises boldly to a height of several feet above the softer granite in its neighbourhood; the structure of many portions of it is spherical and radiated, the crystallization appearing to have acted from many centres simultaneously. Copper pyrites and galena are sparingly interspersed in the mass, which is generally so hard as to render its profitable opening hopeless. Mr. Weaver, indeed, relates that a clump of galena, weighing about a ton, was found near the surface, where the vein enters the mica slate and encloses fragments of that rock, but the general body of the quartz belongs to the category of the "harsh" and "uncongenial rams" of the practical miner.

Within the last few months Capt. Clemes, the agent for the Mining Company, has discovered a north and south lode among the granite precipices at the head of Glendalough, about 80 fathoms west of the spot where the old Luganure vein would be expected to emerge; and a level which has been commenced upon it, only 7 feet higher than Richards's level on the other side of the mountain, has already yielded some highly promising stones of lead ore. A second level has been opened about 46 fathoms lower down, and the piercing of the entire mountain by these galleries at so great a depth below its crest, is calculated, if persevered in, fully to explore its resources, and will probably lay the foundation of a mine which may be wrought with advantage almost for centuries.

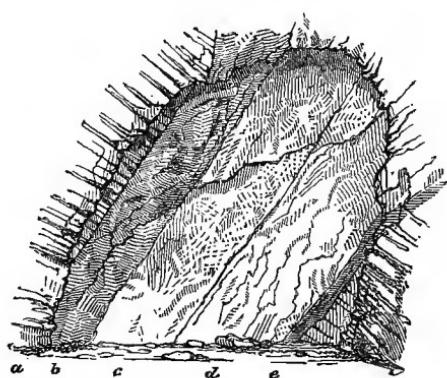
This lode also carries a rib of decomposed granite on its hanging side; and the ore is associated with quartz, baryte, and with, what is unusual in this district, fluor spar of a green tint, and very friable.

Higher up the valley, lead ore has, in inconsiderable quantity, been raised from two localities, the one on the west of a small patch of mica slate, where the lode courses nearly N.N.W., the other farther to the south, where a shaft has been sunk to the depth of 10 fathoms, and some large orey masses extracted but its high and exposed position, which has procured it the name of "Van Diemen's Land" among the miners, has also up to this time been an obstacle to its further examination.

In Glenmalure the phenomena differ materially from those we have been considering; not only is the granite seamed with long strips and patches of included slate, but the lodes, instead of forming a system either parallel with or perpendicular to the meridian, vary considerably from those lines of direction.

The principal vein strikes through the townland of Ballinafunshogue about S.E. by E., and has been proved for above 3,000 feet in length, though little more than a third of that extent has been actively operated upon. At the surface its hade or underlie is towards the south, but, by a return angle to the north as it descends, it remains, on the whole, vertical as far as the adit level, below which it inclines continuously to the north. The dimensions are far more considerable than in the lodes of which we have treated above, sometimes reaching even the width of 3 fathoms, and continued through both granite and slate without particular diminution in one or the other. Three or four distinct bands of various material may always be distinguished, one of which is always without ore, and is evidently due to mechanical action, inasmuch as it is composed of débris of the rock through which the lode at that place is coursing, whether granite or mica slate. Thus, in the accompanying figure, taken at the east end of the 35-fathom level, where both walls of the vein are formed of soft and blanched slate, the central part, of 3 feet in width, consists of fragmentary and triturated mica slate.

Fig. 5.



- a* Slate, wall of the lode.
- b* Galena and zinc blende with spots of copper pyrites.
- c* Broken slate, with slickenside parting on the left side.
- d* Irregular ground with quartz and spots of galena.
- e* Four-inch rib, principally galena.

The portion *c*, "soft" or "vein" ground, is so much less hard than the rest of the lode, or the "country," that the levels are driven in it at a comparatively small expense. The "slickenside" or polished face between *b* and *c* is scored with striae which dip  $20^{\circ}$  to  $30^{\circ}$  N.W., or make a plane angle of  $75^{\circ}$  with the direction of the hade of the vein; showing that if, according to the generally received explanation, these smooth surfaces and grooves are due to the friction caused by the mass on one side of them moving up or down with respect to that on the other, in this case the motion has not taken place in the direction of the hade or underlie of the vein.

In the shaft which is sunk from the adit level, the lode is filled to a great width with hard quartz, but yields ore both on the east and west of it, presenting in the 25-fathom level a width of three feet of almost solid galena, between walls of mica slate. It is observable that when Mr. Weaver wrote, it had been remarked that the vein "proved the most productive in that part where it traverses a very thick bed of mica slate."

This fine mine has suffered under the disadvantage of being at various periods worked in an unskilful manner, which has entailed difficulty and expense on later adventurers; that portion of the lode extending from the surface to the adit level has been almost entirely removed, but in a most irregular way, and the whole is in so ruinous a condition, that it is impossible to approach either of the "ends" or extremities of the workings, on which alone an opinion of the farther resources of the vein can be founded.

The position also of the adit and shaft with respect to each other is so ill-chosen that the apparatus for raising water and minerals is in consequence very disadvantageously applied, and the expenses therefore bear an unnecessarily high ratio to the profits.

In the adit, where the occurrence of numerous strips of slate gives rise to an appearance of its interstratification with the granite, an east and west lode has been intersected, which contains a little galena; and at the back of the old smelting house another, coursing nearly E.N.E. is crossed by the Ballinafunshogue vein. It consists of a dyke of disintegrated granite, with a 4-foot band of hard quartz containing spots of galena, zinc blonde, and iron pyrites, with which is associated fluor spar,

otherwise scarcely ever seen in the district, in small cubes of a purple tint.

In the neighbouring townland of Cullentragh Park, a lode runs N.  $23^{\circ}$  W., consisting of one foot of quartz spotted with crystals of galena, and of a vein of coarse granite, from an inch to a foot wide, on the north wall. On the eastern side of the small workings which have been made upon it, it is met by a cross joint, and lost to view.

On the south side of the valley, nearly opposite to the above, three veins have been slightly operated on, not agreeing in direction, though having one characteristic in common, the presence of baryte, which in two of them occurs in ribs of sufficient width and purity to have been made the object of extraction. They all present galena and zinc blende in small quantities, minerals which in the Clonkeen townland are associated with sparry iron and small spangles of micaceous iron, a substance often met with among ores of copper, although very rarely among those of lead.

Since 1846 a considerable trial has been carried on in the townland of Baravore, upon a strong lode, coursing E.S.E., and bearing galena with zinc blende, copper pyrites, black oxide, and carbonate of copper. It is at present abandoned; but operations have been commenced at four different levels on a north and south lode in the townland of Ballynagoneen, on the north-eastern side of the valley, bearing at intervals the same ores associated with a rib of quartz, which lies on the foot wall, and varies from 6 to 18 inches in thickness. In the "end" of one of these levels was instructively exhibited a vein of about 2 inches wide of almost pure, white, largely foliated mica, which had evidently, after the consolidation of the rest of the lode, crossed through the quartz rib, as well as, more indistinctly, through the soft pink granitic substance which formed the hanging side. This mica vein, however, as well as the rest of the lode, had subsequently been cut through by small fissures, now filled with clay or "flucan," and parallel with the walls of the main vein, which generally were well defined.\*

---

\* This vein is referred to at p. 352.

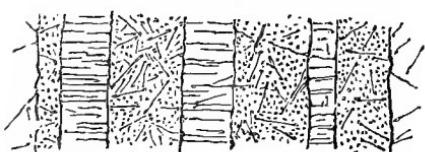


G Granite of the "country."  
G' Softer granite of the vein.

Q Quartz, with a little galena.  
M Vein of mica.

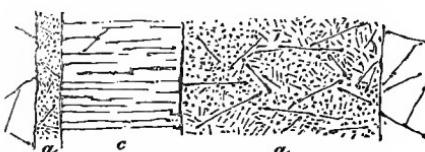
Near the head of Glenmalure, in the townland of Camenabologue, and in the main body of the granite, veins may be observed at two or three places, bearing nearly E.S.E. and W.N.W. They offer no more than traces of sulphide ores, but present, in a marked manner, the same order of parallel ribs of softer granite, which we have pointed out as accompanying the other lodes. The figures appended represent these appearances at two spots, one in the bed of the stream, the other a little to the north of it.

Fig. 7.



a Soft Granite, of medium grain.  
b The same, with a green tint.

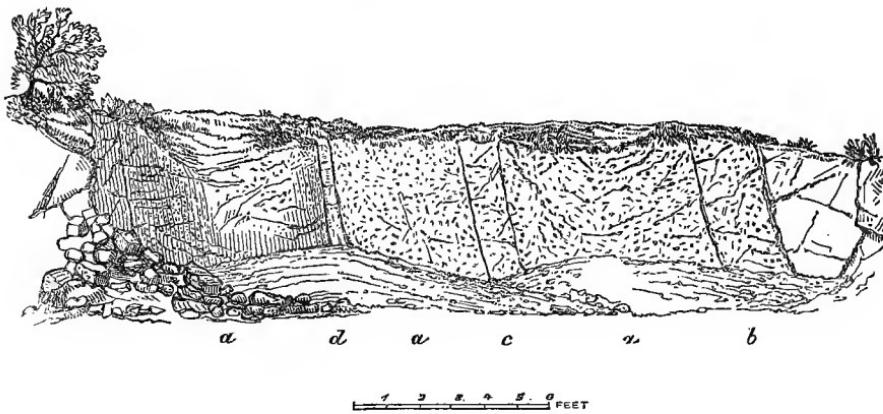
Fig. 8.



c Quartz.  
d Quartz, with specks of copper pyrites.

To the south of Glenmalure, there is only one locality in which lead ore has been found in the granite, viz.: in the side of the waterfall of the Ow River, above Aghavanagh Barrack, where the lode courses somewhat differently from the above mentioned groups, about E.  $40^{\circ}$  S. At the point where it is best exhibited the ore member of the vein is but 3 inches wide, bearing a very small relation to the magnitude of the whole, as may be seen in the accompanying diagram:—

Fig. 9.



- a* Granite of sandy character.
- b* Coarse granite with pink felspar.
- c* Granite containing much steatite.
- d* Quartz with spots of galena and copper pyrites.

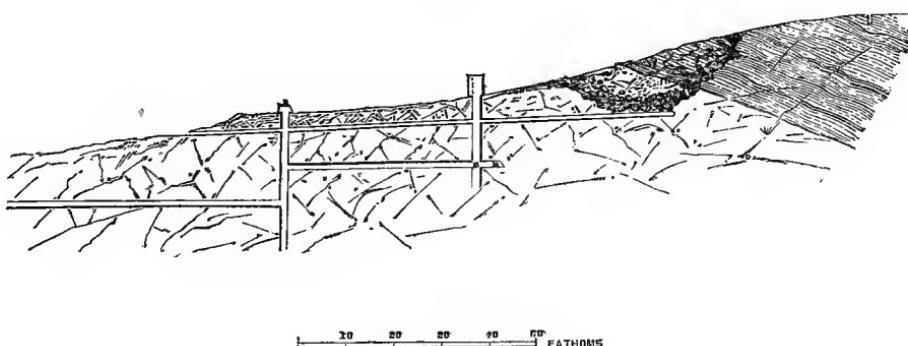
Northward of the two principal mining valleys, and always near the junction of the granite and mica slate, lead ore has been found at several points, at some of which mining operations have been commenced and again abandoned. At the western end of Lough Dan, a lode coursing N.E. by N. and hading  $70^{\circ}$  S.E., is composed of two parts; first, a 2-foot rib of quartz with spots and strings of copper pyrites, galena, and zinc blende; and secondly, 6 to 10 inches of soft decomposed granite, generally occurring on the hanging side. In the levels which have been driven, without much success, upon the vein, it is remarkable that, as we approach the overlying mica slate, fragments of that rock form the filling matter of the lode instead of the friable granite; notwithstanding which, some trenches cut in the slate at the surface have failed in proving that the fissure has been continued more than a few feet in the latter rock.

On the western shore of Lough Tay, a small vein bearing nearly E. and W. exhibits a little galena with iron pyrites, and has occasioned some inconsiderable trials, as have also similar appearances at Djouce and Powerscourt.

At Ballycorus and Rathmichael, in the county of Dublin, several lodes, with a prevailing strike of E. by S. or E.S.E. have yielded small quantities of galena; but only that in the former townland has been systematically opened. The principal vein averages no more than one to two feet in width, and consists of quartz with baryte, galena and zinc blende; but the circumstance which of late attracted most attention was the discovery, in the principal shaft and below the level of the deep adit, of a rib containing native silver; where its occurrence, being in mossy and capillary forms disseminated through a band of greenish quartz about an inch wide, is apparently not the immediate result of the decomposition of the sulphuretted ores, as we have reason, in the case of most of the native metals of our own islands, to infer.

The lode at Ballycorus has been traced for many fathoms into the mica slate, and formed, on approaching that rock, a very productive "bunch" of ore, which has been removed by a surface excavation or "open cast." The accompanying section on the course of the lode will illustrate its geological position:—

Fig. 10.



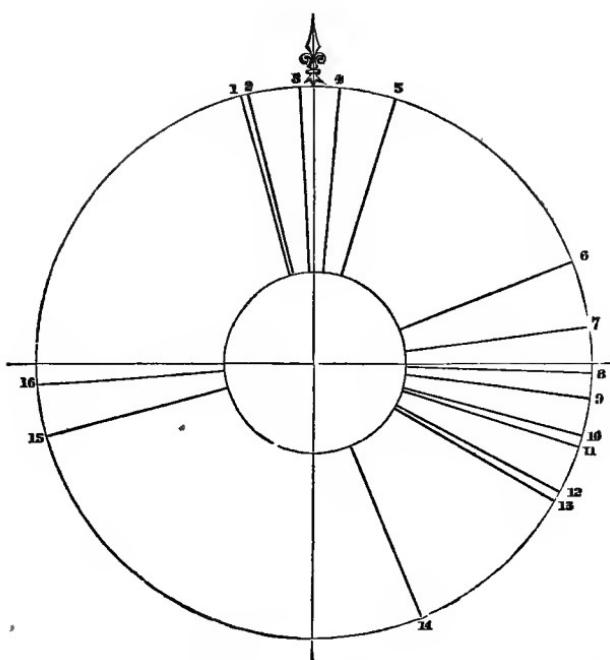
At a distance of 300 or 400 fathoms N.N.W. of the above mentioned workings, it was sought to take advantage of a quartzose vein bearing southward, in order to drive a deep adit level into the Ballycorus mine; but through inadvertence in

piercing a deep accumulation of gravel and sand, the work was ruined shortly after its commencement.

On the coast, at Dalkey, the same geological boundary line is again marked by a lode producing galena and zinc blende, and formed, in great part, of disintegrated granite : from the sea cliff small workings have been opened, but have for many years been abandoned, although according to Dr. Rutty's "Natural History of Dublin," (1772,) some hundred tons of lead ore were obtained from this spot.

If we now take a general review of the above detailed phenomena, although systems of lodes cannot here be distinguished by their filling substances, we shall arrive at a few inferences which may tend to confirm certain positions necessary as a foundation whercon shall be one day reared that oft attempted but slightly advanced superstructure, a theory of mineral veins. In the first place, a ridge of granite mountains striking N.N.E. is skirted on its eastern flank by mica slate, whose outer edge runs in the same direction ; and along the line of boundary, for a distance of 30 miles, mineral veins have been discovered at intervals. Secondly, a great portion of these lodes is always composed either of a granite differing from that of the mountain mass, or of a decidedly disintegrated granite ; proving, in both cases, that fissures have been opened, and then filled either by injected dykes of newer granite, or by the re-constituted minerals or by water-borne detritus of the older ; the latter hypothesis being supported by the few cases in which fragments of mica slate are found where the vein enters that rock. Thirdly, the majority of the veins occupy lines which bear some relation, on the one hand, to the direction of the Wicklow chain, and the strike of its stratified rocks ; on the other, to the line of the meridian ; and whilst the former circumstance has doubtless some connexion with the origin of the fissures, the latter has probably exerted an influence on their filling with mineral substances.

Fig. 11.



- No. 1. Lode of Upper Glendalough.  
 2. Fox-Rock, Glendasane.  
 3. Luganure.  
 4. Hero.  
 5. Ruplagh.  
 6. Glendalough.  
 7. Glendasane.

- No. 8. South lode, Glenmalure.  
 9. Ballycorus.  
 10. Camenabologue.  
 11. Ditto.  
 12. Glenmalure, (Ballinafunshogue)  
 13. Battery.  
 14. Cullentragh Park.  
 15. Lode above the smelting house.  
 16. Clonkeen.

In the above diagram, the upper semicircle includes the courses of the lodes of Glendasane and Glendalough, as referred to the true meridian, whilst the lower one exhibits those of Glenmalure and Ballycorus. The first point which presents itself to our notice, is the decided division into two groups, of which one approximates to the line of the magnetic meridian (which is known within 235 years to have oscillated through an angle of 36 degrees), whilst the other group deviates only slightly from a direction perpendicular to the above. We may be unable, in the present state of our knowledge, to follow up this distinction with the consequence which it deserves; yet it remains a significant fact not unworthy of record.

The perpendicularity of one group to the other, considered without reference to the direction of the magnetic needle, has

been proved by Mr. William Hopkins of Cambridge, in his admirable researches in Physical Geology, to be a necessary result of the upheaval of a mass of three dimensions, acted upon by two systems of parallel tensions. These investigations have reference mainly to the elevation of districts of stratified rocks, but are applicable to the area of massive rock, granite, under notice, whether we consider it under its present denuded aspect, or covered as it probably at some time was, by a crust of slatey strata. Some of the conclusions drawn by him are thus stated :— “ If the mass be subjected to two systems of parallel ‘‘ tensions, of which the directions are perpendicular to each ‘‘ other, two systems of parallel fissures may be produced, of ‘‘ which the directions will be perpendicular to each other. No ‘‘ two systems of parallel fissures could be thus formed, of which ‘‘ the directions should not be perpendicular to each other.” Moreover, “ One system might be formed at any time sub-“ sequently to the other.”

There is no *exact* coincidence between the longitudinal veins before us and the axis of elevation ; but the approximation is sufficiently close, if we take into account the irregularities which might be produced, either by the variable character of the elevated mass, by the sinuosity of the axis, or by the unequal intensity of the elevatory force at different points. A reference to the published map of the Geological Survey, will show that it would not be difficult to reconcile the discrepancies existing between the actual direction of the veins and that indicated by the above laws, if we might assume that the axis of disturbance passed in a curved line from the south-west to Mullacor mountain, and thence towards Tonelagee.

Viewing then the north and south lodes of Glendasane as the longitudinal, we may consider the east and west veins to be the transverse fissures which approximate (Hopkins, § 57) to the dip, as do the former to the strike of the stratified beds. We do not, indeed, find that the observation stated in Mr. Hopkins' introduction (II. §), holds good in the Wicklow range, that a “ large proportion of the most productive mineral veins are found in the transverse system. The longitudinal (frequently termed by the miner *cross courses*) carry ore very irregularly.” Nor have we sufficient evidence of the formation of one set being posterior to that of the other, neither of them being re-

markable for greater regularity or for a peculiar grouping or collocation of minerals.

Concluding, however, with Mr. Hopkins (§ 44), that if we conceive an additional force superimposed on a uniform force producing the general elevation, the longitudinal fissures may be formed first, and a transverse system may be produced at the next instant, or at any succeeding epoch, we shall probably have the true explanation of the phenomena before us ; this conclusion will, however, in our case stand in opposition to that announced in § 70, by which he combats a common opinion of miners, that the dislocation of one lode by another affords a test of their relative age. The *Hero*, *North Rupplagh*, *Fox Rock*, and *Luganure* lodes are all dislocated by east and west veins, carrying a small proportion of lead ore ; and therefore both the theory of the later date of the transverse fissures, and the ordinary notion of the earlier formation of those which are dislocated concur at this place, in assigning the earlier date to the north and south lodes.

It has here been taken for granted that all these veins have been formed by the gradual crystalline accumulation of various mineral substances within fissures previously formed, since no other view appears to be tenable or even explicable ; but as regards the origin of such fissures, it must be admitted that phenomena are observable which may be so interpreted as to render that origin less distinctly dependent on the action of an elevatory force. The direction of the north and south lodes coincides very nearly with that of the principal divisional planes or "joints," which intersect the granite, and range on the average between N. 5° W. and N. 10° E. through a large part of the ore-bearing district.\* It *might*, therefore, be argued that the granite was thus "jointed" prior to the opening of the vein-fissures, and that the direction of these latter was influenced by the planes of division already existing. Yet from the great uncertainty which at present prevails respecting the causes and dates of the "jointed" structure, such a mode of reasoning would only carry us farther back into obscurity ; and it is,

\* Professor Sedgwick, in 1821, observed the parallelism and nearly meridional course of the joints in the granite of south-western England. Cambridge Phil. Trans., vol. i. See also Enys on the Penryn granite, Phil. Mag. 1833, and De la Beche, Geol. Observer, 2d edit. p. 625.

perhaps, not unphilosophical to infer, from the marked relation borne by both these phenomena,—the vein-fissures, and the joints, to the axis of elevation of the country, that we must seek for an explanation of the facts in inquiries analogous to the above, but in which the operation of some molecular arrangement must be superadded to mechanical action.

I have dwelt at some length on this subject, inasmuch as the strike of the most productive veins, although in the cases noticed, diametrically opposite to that observed in most of the well described mining districts, may after all be governed by the same laws, if we regard only a different direction of the elevatory forces, and of the tensions consequent on their action, at any given period.

---

### *Mines of the Slate District.*

The clay slates which form the principal constituent rock of the county of Wicklow are not, as a whole, remarkable for the presence of metallic minerals, either disseminated, or in veins; but a band or "channel" of about 600 fathoms in width, coursing from the north flank of Croghan Kinshela for about 9 miles in the direction N. 40° E., exhibits at intervals a variety of metallic ores, which being in certain spots accumulated in larger quantities than elsewhere, have given rise to the long-continued mining operations of the Vale of Ovoca.

The slates in question, which from the fossils occurring near Rathdrum, are referred to the lower Silurian period, are thinly laminated, and very uniform in strike and dip, though differing so much in mineral composition as to pass through many gradations of argillaceous, talcose, felspathic, and greenstone slate. Considered under a general aspect, the hornblendic varieties occur chiefly on the lower or "lying" side of the metalliferous portion, whilst the hanging side is occupied, on both sides of the Ovoca, by extensive roughly bedded masses of a felstone, or silicious felspar rock, which gives rise to most of the precipitous forms between the Meeting of the Waters and the Wooden Bridge.

Commencing with the south-western end of the line in question, we find in Ballycoog and Moneyteige hills, that small workings have long ago been commenced, and from time to time resumed, on beds of magnetic and oligist or specular iron ores, associated with copper pyrites, quartz, and chlorite. These deposits are in each case two in number, at a small distance apart, and varying from a few inches to 6 or 8 feet in width. The copper ore near the surface is too sparingly mixed to occasion a profitable extraction, and the iron ore, rich though it be, has not been proved to exist in sufficient mass to render larger operations advisable. The same veins, on the banks of the Aughrim river, present but small threads of pyrites; but at Knocknamohill and two other points within a mile to the north, deposits of an analogous nature, bearing much the same direction, but not in a continuous line, exhibit considerable quantities of specular iron ore, and iron pyrites associated with quartz and chlorite, and interspersed with small patches of copper pyrites. Farther to the north-east, however, in several parallel lines, these indications become more pronounced, and the veins, interrupted only by a large fault, are continuously worked along an extent of 2 miles, varying occasionally in the number of workable deposits as well as in the nature of the minerals exhibited.

There is, perhaps, no tract in the British islands which exhibits, even to the eye of the uninitiated, an appearance so strongly stamped with the characteristics of the presence of metallic minerals. For a considerable distance on both sides of the deeply-cut valley of the Ovoca the face of nature appears changed, and instead of the grassy or wooded slopes, or the gray rocks which beautify the rest of its course, we see a broken surface of chasms, ridges, and hillocks, glowing with tints of bright red and brown, or assuming shades of yellow and livid green, which the boldest artist would scarcely dare to transfer to his canvas. Here and there from among the ruins peers the white stack and house of a steam-engine; or water-wheels stand boldly projected against the hill-side,—some still and neglected, others whirling round in full activity; long iron pump rods ascend the acclivities to do their work at distant shafts, and as long as daylight lasts, the rattle of the chains for raising the ore, and the clink of the separating hammers attest the vigour of the operations. In truth, quite independently of the geological or

mining interest of the place, a walk through this series of mines, especially on a sunny evening, will yield a harvest of novel and striking scenes, the effect partly, of the features of the mineral ground, and partly of the fine distant prospects which the higher workings command.

The first of these mines on the west is Ballymurtagh, at present in the occupation of the Wicklow Copper Mining Company, and producing large quantities of copper ore and iron pyrites. The surface has been marked by huge projecting masses of "gossan," or hydrous peroxide of iron, resulting from the decomposition of the ores, but has been much changed in appearance by the great activity of the operations during the last few years. The principal feature is the great metalliferous deposit which dips with the slate at angles of  $40^{\circ}$  to  $60^{\circ}$  S.E. and consists, at a small depth from the surface, of 12 feet in width of granular iron pyrites, locally termed sulphur ore, of a pale colour, altogether free from gangue or vein-stone, not bounded by distinct walls, but ceasing by gradual interlamination with the clay-slate. On the north to the distance of 100 fathoms, and on the south for 20 fathoms, parallel veins of cupriferous pyrites have been met with, sometimes very numerously; but only in the case of those which lie within a distance of 50 feet to the south, profitable in extraction. The iron pyrites has not been found in available quantity at a greater depth than 100 fathoms; it appears to grow thinner at about 80 fathoms from the surface, and then to unite with the copper "lodes," as they are termed, on the south, forming together at the 56-fathom level a "bunch" of copper ore, 24 feet in width. This vein was in one spot by the addition of numerous bands of greater or less thickness, and on both sides, increased to nearly 60 feet, and had been worked away in one huge cavity of such dimensions as are rarely seen in metallic mines.

The copper "lode," although varying much in thickness, has none of the characteristic appearances of a vein; its ore is the double sulphuret of copper and iron or ordinary copper pyrites, and is of a very low per-centge owing to the admixture of iron and of portions of quartz and talcose or sometimes chloritic slate, never occurring in a fragmentary state, but interlaminated sometimes so delicately as to appear in fine films, and contorted like the adjacent rock. It may even be remarked of the masses

or "cobs" of ore brought to the surface, that when struck with a hammer they have no tendency to break with the usual fracture of copper pyrites, but split in the direction of the lamination.

As an exception to these appearances, a cross-fissure, the sides of which were encrusted with crystallized copper pyrites and quartz, was found between the 33 and 66-fathom levels; with a course nearly at right angles to that of the main lode, it came up to, but did not pass its north wall, and thus presented a character analogous to certain veins which will be described in Tigroney mine. Its width was irregular; yet was sufficient to enable it to be worked "on tribute" for some 20 fathoms in length.

In the western portion of the mine, which has not long been opened, the copper lode has been found in good force, and produces a better description of ore; in the 100-fathom level, at the new shafts, it is as much as 6 or 8 feet wide, and the walls, as usual, are ill-defined, from the "country" being impregnated with ore on both sides of the main deposit. Even in the bottom of the 110-fathom level, which is but lately completed, fair "bunches" of ore are seen.

On the surface of the hill, about 120 fathoms to the north of the principal vein, large masses of "gossan," composed chiefly of fragments of slatey rock cemented by brown oxide of iron, had long ago induced the commencement of mining operations. It is, however, only within the last three years, that more efficient trials have been crowned with the success of discovering a parallel course of iron pyrites of remarkable size and solidity. Two principal shafts have been sunk upon it to the respective depths of 40 and 60 fathoms, and a third has been commenced with the view of intersecting it at a depth of 60 fathoms, further westward. "Levels" or galleries have been extended in it at the depths of 20, 30, 40 and 60 fathoms to lengths varying from 20 to 30 fathoms, and the whole of the ground thus opened proves to be productive, the breadth of the new lode averaging 24 feet.

With the view of working this fine discovery to the greatest advantage, an adit or water gallery, called Margaret's level, has been driven up so as to intersect the north vein at 60 fathoms deep; and another which will unwater it to a very much greater

depth is driving from the road side, nearly at the level of the river, in a vein offering appearances of considerable promise.

Two intermediate lodes have also been discovered by the same operations, one of which offers a good width of iron pyrites with  $1\frac{1}{2}$  per cent. of copper, and occasional ribs of higher produce.

By the kindness of E. Barnes, Esq., M.R.I.A.,\* the resident director, the survey has been furnished with the following Table of the Statistics for eight years previous to 1852.

PRODUCE of BALLYMURTAGH MINE, County Wicklow.

Year.	Copper ores. Tons.	Sold at Swansea. Tons.	Sold at other ports. Tons.	Gross value. £	Pyrites. Tons.	Net value. £	Paid in wages. £
1844	7,130	3,635	3,495	18,166	9,575	7,420	14,429
1845	6,816	2,836	3,980	17,871	11,943	9,337	14,885
1846	7,318	2,564	4,754	16,046	11,023	9,445	14,395
1847	6,012	964	5,048	11,851	13,503	12,928	13,795
1848	7,621	1,317	6,304	15,022	8,969	9,865	—
1849	7,783	1,233	6,550	15,342	9,582	10,540	—
1850	6,754	339	6,415	13,313	14,873	16,360	—
1851	6,026	102	5,924	11,878	21,738	23,911	—

About 800 persons have been in constant employment, from 300 to 400 of whom worked underground.

With regard to the working of the mine, unskilful methods were employed for many years, which have repeatedly endangered the whole of the underground ways and those engaged in them. The practice of "underhand stopeing" was always adopted, from unwillingness to allow time and money for properly opening out the ground, and conducting the operations on the principles recognized as the best in Cornwall, Saxony, the Hartz, &c. During the last few years, the system of "stopeing in the back" has been introduced, a pair of shafts have been sunk at the extreme western end of the mine, and the 110-fathom level is to be driven at once beneath all the old workings, by which means

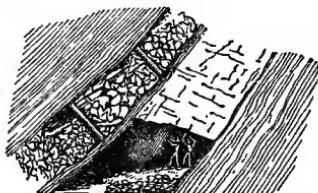
\* I may here express my obligations to this gentleman and his agent, Captain Roberts, as also to Mr. Petherick, and Captains Barratt and Clemms, of the Lulanure mines; to Mr. Hodgson and Captain Webster, of Ballygahan; Captains Reid and Lane, of Tigroney; and Captain W. Roberts, of Connaree mine, for the facilities afforded in the mapping of the surface and in the underground examination of these mines.

the stability of the mine, from a certain depth, will be ensured, and the water which must at present be raised by horizontal rods from all the "bottoms" will be lifted in a direct line.

The large dimensions of the excavations, precluding the aid of timbering, have caused terrific crushes, attended fortunately as yet by no loss of life. In 1835 a great fall of the solid iron pyrites occurred ; from the roof of the 18-fathom level, a mass 30 fathoms long, and 20 fathoms deep, (at an average of 10 feet wide, weighing near 30,000 tons) broke away, and crushed through all the levels to the bottom. The previous sounds of rending and the smell of sulphur diffused by the friction, warned most of the men to escape ; and even the rats, which were living in great numbers underground, fled to the surface ; 18 men, however, who took refuge in a freshly driven gallery were immured at a great depth from the surface, and extricated only after a couple of days passed in the most frightful anxiety, by an orifice accidentally left, and found to extend throughout the heap of ruins.

On St. Patrick's day, 1845, at 10 P.M. when no one was in the mine, another tremendous "run" occurred near the eastern boundary. Extensive workings had been carried on by the "old men" in the copper lode, and had been filled up with "deads," or refuse stone ; from the absence of plans, however, their actual extent was but little known, and yet they were divided by a parting of only a few inches thick from the modern excavations in progress on the "sulphur course," where the latter was very wide.

Fig. 12.



A few heavy "slobs" or platey masses had fallen down previously ; but on this night the whole barrier gave way, and the old "deads," solid as they were, broke in like a stoney torrent, and forced their way down to the 33-fathom level, forming a mass of shattered rubbish from the surface to a depth of 70 fathoms, and swallowing up in the vortex various buildings

which had been erected over it. Had the event occurred on a working day, 30 or 40 men must have been killed.

A considerable force of machinery is employed at Ballymurtagh, consisting of, 1st, a Cornish pumping-engine with a 51-inch cylinder at the western shafts; 2d, the old eastern engine, with a 30-inch cylinder driving a whim, and also 24 stamp-heads; 3d, two whim-engines of smaller dimensions. It is remarkable that notwithstanding the poorness of the ores, no mechanical power is at present brought to bear on their "dressing" or preparation for the market; and apparatus which in other copper-mining districts is largely employed for that purpose, is said both here and on the eastern bank of the Ovoca to have been tried and rejected. The peculiar flakiness of the ore, and its great admixture with iron pyrites, operate as causes of difficulty, and the quickness of the boys engaged in hand-picking enables the ore to be "cobbed" and picked for 6s. a ton.

In the second of the Ovoca mines, Ballygahan, worked by Mr. Hodgson of Ballyraine, the same general characters are continued. The pyrites deposit, which near the surface averages 3 fathoms in width, swells out at the deep adit level, west of the "Blue shaft," to 36 feet, exclusive of a south rib of 4 feet, containing a proportion of copper pyrites; and at the deeper levels, 60 and 70 fathoms below the adit, diminishes to 2 or 3 feet. The "coppery rib" above mentioned is succeeded at 9 fathoms farther south by the "main lode," (which above the adit level has also a "north branch,") at 2 fathoms again by "Barry's lode," and at 2 fathoms farther by "Tukes's lode," all of them irregular deposits of copper ore, without very definite walls or the admixture of the vein-stones characteristic of mineral veins. The "copper lodes" have long since had all their most profitable parts extracted, and the cavities are filled with "attle" or refuse (remblais of the French), which has become strongly cemented together by the oxide of iron deposited by the mine waters in consequence of the decomposition of the pyrites; they have been almost neglected since the demand for "sulphur ore" arose, and have therefore not been investigated to the same depths as the principal or "champion" lode.

Westward of the engine shaft, 112 feet, the pyrites course is met by a "slide" pointing a few degrees west of north, and is heaved to the south a distance of 55 feet, whilst the "copper

lodes" appear to be unmoved by any dislocation, and are thus much nearer to the great deposit in the western, than in the eastern part of the mine.

Thus fig. 13 will represent a vertical section, in a south-east and north-west direction, of the several veins as seen at the engine shaft, in the 18-fathom level, and fig. 14, a section of the same veins in the 15-fathom level above the adit, at Brownrigg's shaft, the distance between the two sections being but a few fathoms.

Fig. 13.

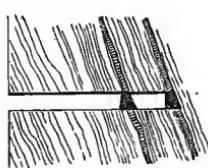
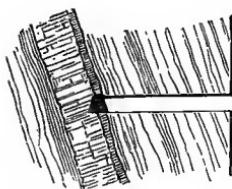
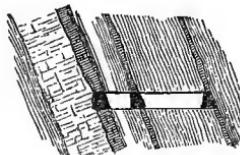


Fig. 14.



— 70 80 90 100 110 — FATHMS —

This remarkable point, to which we shall again advert,—one of the very few which afford a proof of the introduction of the mineral veins being subsequent to the deposition of the slatey rocks, is, with many of the concurrent phenomena, clearly exhibited in the 6-inch map from which the geological lines of the published map of Wicklow have been reduced, whilst the principal workings, and the very interesting transverse sections afforded by these several mines, are represented on a larger scale in the separate sheet of the Ovoca mines published by the Geological Survey.

About 15 fathoms east of the "Blue shaft" the "sulphur-lode" is heaved a few feet to the north; and 30 fathoms farther, two more dislocations occur, the fragment of lode being in each case about 2 fathoms long, and separated from the other part about 3 fathoms. Towards the river, it seems probable that the more considerable disruption takes place, which heaves or throws the beds in a horizontal direction to the northward, to Tigroney mine. Immediately to the south of Ballygahan mine, the ordinary slate is succeeded by the silicio-felspathic masses forming the "Bell rock;" and some uncertainty has been felt as to whether this rock would interfere with the continuation of the metalliferous beds in their prolongation beneath it. It

would, however, now appear that it overlies the slates in the sense of their stratification, and therefore would probably exert no influence on their productiveness.

Ballygahan is relieved of water by an undershot wheel placed in the bank of the Ovoca, whilst a water-wheel of 50 feet diameter, and 30 inches breast, draws from the engine shaft; and a double wheel of 32 feet diameter, with 15-inch buckets, from the "Blue shaft."

The iron-pyrites has been, till within 2 or 3 years, judiciously extracted from chambers of limited length and height, between which "arches" of sufficient strength were left to sustain the walls; and in this manner Ballygahan long escaped the terrible "runs" which have endangered its neighbour mine.

The increased demand for "sulphur-ore" since 1846 induced the managers to cut away some of the buttresses which had hitherto given security to the excavations, and the almost inevitable result was that a terrific crush took place in May 1850, which engulfed the surface, with a house standing upon it, and an unfortunate child that had not fled in time from the treacherous spot; and this, coupled with the minor settlements which have since taken place, has given to the hill side the appearance of a frightful ruin.

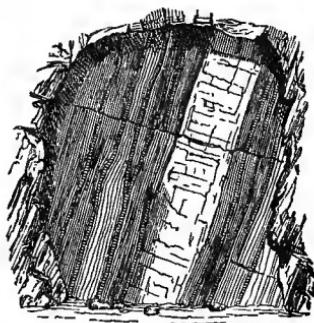
On the northward, to the distance of half a mile, ores of a similar nature, but in small quantity, are occasionally mingled with the slates; and at Kilcashel and Upper Ballymurtagh have given rise to extended mining trials.

On the eastern side of the Ovoca, at the mines of Tigroney and Lower Cronebane, the beds of decomposing and variously coloured slates, together with the "sulphur course" and the "copper lodes" on the south, are evidently the continuation of the deposits of Ballygahan, dislocated to the horizontal amount of about 1,000 feet.

The iron pyrites runs to 20 feet in width; and the clay-slate at its side is for 3 fathoms of a dark colour, smooth, and softer than at a greater distance. During the great demand for sulphur in 1841 and 1842, upwards of 2,000 tons of this ore were raised per month. In 1846 the work was concentrated upon the copper ores, but subsequently the pyrites has been very largely extracted. At greater depth, the main deposit again seems to diminish; and in the 10-fathom level (below the

adit which mouths a few feet above the level of the river) it presents a width of only 14 inches, with the accompanying appearance.

Fig. 15.



In the above figure the light coloured band represents the iron-pyrites ; the narrow ribs with transverse lines are "strings" of slightly cupreous iron-pyrites.

The "copper lodes," which are very irregular, but more or less parallel to the pyrites course, commence almost immediately on its south wall, and are sometimes seven in number, besides occasional intermediate ribs, within a width of 20 fathoms, so that the ground is worked away in stopes of 14 or 15 feet wide for considerable distances. The ore is in general tolerably clean, but only produces from 4 to 8, and rarely 10 per cent. Cross-cuts, driven 20 fathoms farther to the south, have not met with any metalliferous deposit.

Near the first "copper lode" the slate is often much wrinkled, though its general inclination is  $60^{\circ}$  to  $70^{\circ}$  S.E. The lode is in most respects similar to those above described, but is here sometimes interrupted by a cross deposit of limited length, which appears to stop it for a time on its line of strike, as in the figure.

Fig. 16.



Such T's, as they are called by the miner, are productive of copper ore of somewhat higher per-centge than that before mentioned, associated with a little quartz and chlorite; and

extend in the cross portion to a length of 8 or 10 fathoms, and height of 20 or 30. They possess also a high importance, in any considerations on the nature and origin of the metalliferous deposits of the Ovoca, for they clearly prove that other forces have been superadded to simple deposition,—a fact not so distinctly elucidated on the western side of the river, although paralleled in one case by the cross fissure at Ballymurtagh, adverted to in p. 373. Such richer parts have been described by Weaver as “contemporaneous veins,” bearing copper pyrites with 10 to 12 per cent. of copper, and sometimes a width of 4 or 5 feet of solid ore.

Towards the N.E., beyond the “Mosey” shafts, the strike of the beds appears to have suffered some disturbance, and their continuity is somewhat uncertain, since through a space of 800 feet in length, no workings have been carried on, with the exception of some shallow shafts, long since filled up. A little farther, however, the ore deposits, skirting on the south the knoll, surmounted by the remarkable transported boulder of granite, called the Motto Stone, come in contact with the silicio-felspathic rock, and continue along its under side for nearly a mile. The mine of Upper Cronebane consequently presents features very different from those exhibited farther west. The principal deposit consists in a great measure of the sulphuret and the black oxide of copper, associated with soft clayey matter or “flucan,” and appears in depth to pass into pyrites. The north or “lying” side of the lode is at first occupied by 6 to 10 feet of a black, smooth carbonaceous clay-slate; but is farther eastward replaced by a white argillaceous mass, containing one or two thin bands of carbonaceous matter, and occasionally rounded and isolated lumps of galena. The beds are affected by many sharp turns and twists, although their continuity is apparently unbroken; and at such points the carbonaceous shale is particularly contorted and shattered. The inclination is also subject to sudden alterations, and varies from  $60^{\circ}$  to  $25^{\circ}$ .

At the surface the outcrop of the principal deposit is marked by a strong gossan, or brecciated mass of slatey rock and brown peroxide of iron, which about the middle of the last century was found to contain native silver in very minute particles. This metal was extracted by fusion with lead and cupellation, and was proved to yield 30 grains of gold in the ounce, or  $6\frac{1}{4}$  per cent.

The apparent relation of the black ore to the felspathic rock is well exhibited in the workings. Reid's shaft is sunk through a mass of this kind, yellowish white in colour, and hackley in fracture. On the west, a large development of "flucan" contained pyrites and a blueish black copper ore,—the latter being the most usual, even at the depth of 33 fathoms. About 70 fathoms farther west, the "soft white ground" ceased, and was succeeded by a dark and hard slate, in which the ore died away; and the same phenomenon was repeated in all the successive levels. Parallel deposits of ore, about 450 feet on the south, were intersected by the "Lodge level," which though analogous in position to the productive lodes of the lower mine, have been for many years neglected.

Upper Cronebane has laboured under the disadvantage of having no outlet for the subterranean water, although situated on very high ground, and its powers of production have not therefore been fairly tried. Few situations could offer a finer opportunity for the establishment of an extensive mine without the necessity of engines for raising water, and with the favourable prospect of intersecting several courses of ore, which are known to have been productive at shallow levels. If the deep adit were prolonged some 500 fathoms, it would arrive beneath the upper mine at a depth of no less than 100 fathoms; and whatever ore were thus discovered, would be extracted with a facility unusual in copper mining, whilst the important advantage of a convenient locality for "dressing" the ore would be obtained,—a process which when rudely conducted, as it must be in the present exposed position of the "floors," is fatal to an ore so specifically light as the black oxide of copper.

The working of the mines had for some years been conducted in an unskilful manner, but since they have been in the hands of the Messrs. Williams of Cornwall, much has been done in clearing and making everything secure. The levels are of dimensions consistent with the best principles of mining; and the lode is regularly worked in stopes; the "deads" thrown under foot; and thus, notwithstanding the width of some of the excavations, accidents never occur.

Stone-walling or "stullen" is used to great advantage, where the slatey rock is sufficiently hard; and in the timbering it is found that the Irish larch and Irish-grown Scotch fir (*pinus*

*sylvestris*) last remarkably well, even, as the captains of the mine assert, better than Norway timber.

The copper ores exported from Cronebane and Tigroney and sold at the Swansea ticketings, appear to have been as follows, for the last nine years :—

—	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.
	Tons.								
Cronbane -	819	1,635	2,325	1,241	137	—	13	—	25
Tigroney -	353	657	644	422	—	—	13	—	—

The machinery employed for various purposes, is as follows :—

1 undershot water-wheel of 19 ft. diameter, and 7 ft. breast, pumps from 40-fathom level.

1 undershot water-wheel of 20 ft. diameter, and 7 ft. breast, drives 10 stamp-heads.

1 overshot water-wheel of 50 ft. diameter, erected for stamping and jiggling the ore.

1 overshot water-wheel of 40 ft. diameter, occasionally works the pumps.

1 overshot water-wheel of 40 ft. diameter, drives 10 stamp-heads.

1 steam-engine of 24 inches cylinder, draws at the Boundary shaft.

A more powerful steam-engine was erected some time since by Mr. Johnson, aided by a loan from the Government, for the purpose of stamping on a large scale the "burrows" or old mine heaps which had been represented to contain a useful proportion of copper. False results had however been obtained through the fraudulent conduct of the dressers, who made the experiments; and the whole scheme necessarily fell to the ground.

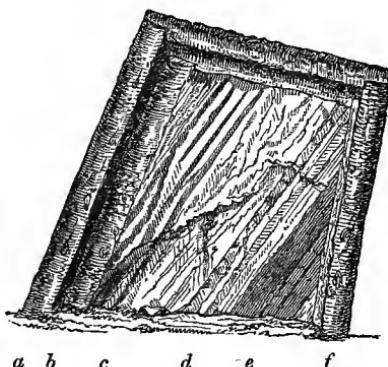
Pursuing its course to the north-eastward, the same series of metalliferous deposits has been explored in the mine of Connary for a length of 400 fathoms, and to the depth of 84 fathoms. The sulphide with black oxide of copper has also here been the predominant ore, associated with argillaceous matter or "flucan," and sometimes with portions of galena, antimony glance, and zinc blonde; in certain spots, as near the Cross roads, it has

been found within 6 feet of the surface, and is generally covered by a mass of "gossan," from 6 to 10 feet in depth.

The dark ore of copper, which forms so remarkable a feature in these mines, might at first readily be taken for the black oxide alone, of which indeed those portions near the surface chiefly consist; but a closer examination shows that extremely minute crystals of copper glance, or sulphide, are agglomerated into a granular and friable substance, and are in places more or less decomposed into the oxide. The mineral occurs in strings from the finest thread to a foot and upwards in width, running parallel with the plane of the lode and the beds of the slate, and accompanied on one side by bands of iron pyrites; it has been found to a depth of upwards of 35 fathoms from the surface.

The accompanying section is taken from the 35-fathom level, near the boundary on the west, at a spot extremely valuable as well from the rich nature of the ore as from the softness of the gangue and country.

Fig. 17.



*a* SOUTH OR HANGING WALL; white soft slate.

*b* Thick strings of black oxide of copper, interlaced with "flucan," full of interspersed pyrites and specks of black oxide.

*c* Irregular strings and fragmentary portions of quartz.

*d* Ribs of granular pyrites, with a little "flucan" or argillaceous matter.

*e* Eighteen inches of black shale.

*f* NORTH OR FOOT WALL; gray slaty rock.

There occurred near this place, some years ago, a "bunch" of ore 72 feet in width, the "flucan" of which is said to have been succeeded in depth by pyrites.

In the deeper levels the principal ore mass has been in some localities 4 fathoms wide, composed principally of iron, somewhat

intermixed with copper pyrites, and exhibiting a little black copper ore even to the depth of 70 fathoms. In the "backs" above the 60, it is divided into two, a north and a south rib, the latter of which is formed of 8 to 10 feet wide of solid iron pyrites, the central part having a cellular structure, and features more akin to those of a true vein, whilst the frequent lining of joints and cracks by a film of crystalline native copper proves that *anogenic* chemical action, or that which proceeds downwards from the surface, has been rife even to a great depth, and may have modified the appearance of ores which have withstood complete decomposition.

At the 84-fathom level, the "sulphur course" is between 8 and 10 feet wide, and still yields iron pyrites, occasionally containing portions of copper ore.

Several irregular copper lodes occur on the south, all confined to the silicio-felspathic rock, the thickness of which is nearly 700 feet, measured along the surface; one of them only has been reached by cross-cuts from the workings, and in no case was it tried for more than a few feet in length.

Near the extreme east of the workings the white massive rock, which for so great a distance has formed the "hanging wall" of the metalliferous bed, begins to appear on its northern side, and is succeeded by a narrow band of slate, so as to present the appearance of having been diagonally intersected by the lode. The relations, however, could not be duly investigated at the time the survey was on this ground, since the eastern mine, approached by the north adit, had not for a considerable period been in operation; they may, however, probably be explained by the very unequal accumulation of the felspathic rock, which is sufficiently evident on an inspection of the map.

Beyond this point no very spirited mining operations have been conducted, although the appearance of ferruginous slates, sometimes accompanied by pyrites, have led to the commencement of trials at various localities for three or four miles nearly along the same line of strike.

Connary was for some years subjected to a disgracefully bad management, by which the ore was removed without any regard to system or to future consequences, and the workings were crippled and rendered highly unsafe. Much has, however, now been improved; and if a deep adit were driven up from the

valley of Ballykean on the east, in such manner as to spare the heavy expenses of pumping, the mine would present considerable promise of future good fortune. A steam-engine of 30 inches cylinder is taxed to its utmost in keeping the water, whilst a whim-engine of 18 inches cylinder is used for the extraction; but the expense in fuel necessarily weighs heavily on the production.

Throughout all the mines above mentioned the juxtaposition of large quantities of pyrites with clays and soft slates, combined with their exposure to air and the percolation of water, produce various decompositions, which exhibit their effects abundantly in the old workings, under the forms of blue and green vitriol, and other sulphates. The water, trickling through old excavations, continually dissolves a portion of these salts, and at its exit from the mine is carefully led into inclined troughs or "launders," in which fragments of scrap iron are laid. At the expense of the sulphate of copper, sulphate of iron is then formed, and the metallic copper is precipitated, and from time to time collected. This method of extracting a large quantity of valuable metal, which would otherwise run to waste, would appear not to have been practised in the time of Agricola, although in his laborious work on minerals, published in 1546, he frequently treats of coppery waters (*aquæ aeratæ*), and expressly mentions the water drawn from a shaft at Schmölnitz, in Hungary, "which "erodes iron and turns it into copper," (*talis in Cepusio Smolnicii aqua putealis, quæ ferrum erodit, et vertit in æs*).

The same district is probably alluded to by the Cavaliere Bonardo Frattegiano, in his curious work called *La Minera del Mondo*, published at Venice in 1584, where, in speaking of rivers, he relates that "in the territory of Buda, in Hungary, "there is a rivulet in which, by repeatedly placing iron, it "becomes Cyprian copper."\*

A process similar to the modern one was, however, described by Dr. Edward Brown, in his travels published in 1685, and in a paper in the *Philosophical Transactions* for 1670, when describing the mine of Herrengrund in Hungary, he relates, "There are also two springs of a vitriolat water, which turn

\* "Nel territorio di Buda in Ungheria è un rivoletto, nel quale ponendosi più volte il ferro, diventa rame Cipriotto."

" iron into copper, called the old and new Ziment ; these springs " lie very deep in the mine, and the iron is ordinarily left in the " water fourteen days. These waters are very profitable, seeing " that the worst sort of iron, and useless old iron, is hereby " turned into the purest sort of copper, which hath this com- " mendment above other copper, to be more ductile, malleable, " and easily melted. Some will not have this to be a Transmu- " tation of one Metal into another, but that this water of the " Ziment being saturated with a *vitriolum Veneris*, and meeting " with such a body so ready to receive it as *Mars*, it deposes " *Venus*, who immediately insinuates herself so far into *Mars*, " that she doth *dividere et imperare*, and at last she substitutes " her own body and precipitates that of *Mars*."

From a letter of the Rev. William Henry, D.D., inserted in the Philosophical Transactions for 1752, we learn that the existence of copper in solution in the water flowing from Ballymurtagh had only lately been discovered by accident, but had given rise to extensive apparatus where 500 tons of iron were at the same time employed to effect the precipitation of the costlier metal. The mode of operating was very rude ; pits were dug, 10 feet long, 4 wide, and 8 deep, floored with flags, and lined with stone, and the iron bars were laid on rough wooden beams fixed across from wall to wall. Dr. Henry's statement of the everlasting efficiency of the water, shows that, by him, at least, the rationale of its action was little understood. "Chains of " these pits are continued along the stream, as far as the " directors please, for the water never abates of its quality, if it " were conveyed from pit to pit through a thousand!"

By this mode a ton of the precipitate obtained from the pits yielded 16 cwt. of the finest copper.

Dr. Rutty\* states, that in seven years previous to 1765 the Cronebane water had yielded 17,260*l.* from precipitate copper ; the precipitate affording above half of pure metal.

Towards the close of last century, copper was obtained by the same means at Cronebane and Tigroney. According to the Journal des Mines, vol. iii., it was usual to add to the strength of the solution by placing in the water a quantity of the poor pyritous ore which had undergone a process of roasting. The

---

\* Natural History of Dublin, 1772.

form of the pits is not described, but the ratio of pure copper to the precipitated powder was only 0·328.

The quantity of precipitate or cementation copper exported to England was, in 1788,  $11\frac{1}{2}$  tons; in 1789, 37 tons; in 1790,  $59\frac{3}{4}$  tons.

During Mr. Weaver's management, the water was run into tanks, in which the muddy particles were allowed to subside, and then passed into pits filled with plate and scrap iron; the quantity precipitated during that series of years was  $442\frac{1}{2}$  tons, which sold on an average at 27*l.* 8*s.* 9*d.* per ton, being in aggregate value, 12,126*l.*; whilst the consumption of iron was rather less than one ton to the ton of the precipitate.

At the present date the water is economised at all the Ovoca mines, but by a somewhat different method; it is led through a series of narrow troughs or launders, inclined at angles of  $10^{\circ}$  or  $12^{\circ}$ , and interrupted at intervals by a deep chest or "hutch." At Tigroney the precipitate is swept down with brooms every night and morning into the hutches, the contents of which are afterwards mixed, and realize 50 to 60 per cent. of copper. The expenses of obtaining it are about 3*l.* per ton for attendance, sifting, &c. At Connary people are kept sweeping down the launders throughout the day, by which means the precipitate, although more rapidly collected, is more impure, yielding but 43 to 54 per cent. of copper.

The mode of treating the cupriferous water in Hungary, as I have seen it practised at the interesting mine of Herrengrund, near Neusohl, the same as described by Brown in 1670, is to run it through an inclined trough of about 100 fathoms in length, throughout which boards are placed in such manner as to form a succession of steps, the floor of each inclining a little backward, and on these steps are placed fragments of scrap iron, which are left undisturbed for a period varying from a week to a month, and are then coated with a precipitate of such purity as to produce 70 to 90 per cent. of metal. It remains, however, to be proved by experience at what angle the "launders" should most advantageously be inclined, and how far the more rapid collection of the precipitate may make amends for its inferior quality when frequently swept, as at Tigroney and Connary.

With respect to the early history of the mines of the Ovoca, we may rest satisfied that whatever can be gleaned on the

subject has been collected by the labours of Colonel Vallancey, and we need therefore only cast a retrospect over their condition in the last century, whence it is possible that some hint may be obtained applicable to some of the uncertain ground on the east bank of the river.\*

Dr. Henry stated in 1752 that the mine of Ballymurtagh had been for some years "disused," although before that time it had yielded great profits. Cronebane, on the other hand, employed 500 men, and some of the shafts had already been sunk from 50 to 70 fathoms in depth. It would appear that the shallower workings yielded lead and silver ores, as was more recently the case on the eastern prolongation of the beds. "In sinking the " shafts, the first mineral met with is an ironstone. Beneath " this, they arrive at a lead ore, which seems mixed with clay, " yet yields a large quantity of lead and some silver. Under " this lies a rich rocky silver ore, which sparkles brightly, and " yields 75 ounces of pure silver out of a ton of ore, besides a " great quantity of fine lead."

In the third volume of the *Journal des Mines*, published in 1794-5, it is stated that the Ovoca mines had been in continual

---

\* In connexion with the history of the ancient workings at Cronebane, I may advert to a remarkable spot to which I was guided by Captain Reid. On the east of the engine shaft, the level, 20 fathoms under the surface, has been driven into a conglomerate of slate, pyrites, quartz pebbles, and granite boulders, slightly cemented by argillaceous matter; the same substance had been seen 4 fathoms deeper, and was penetrated several fathoms in length, being sufficiently consolidated to hold together for some time without timbering. This appearance of rounded masses of granite, occurring at a depth of 140 feet from the surface, had astonished the agents of the mine, who were indisposed to consider that old workings had been filled up with those materials, because no tradition of excavations in this part of the mine was known; and again, because fragments of good copper pyrites are met with amid the mass, which they supposed would not have been neglected by the miner. Looking, however, at the recent date of the utilisation of copper pyrites in our islands, and the probability of deep open workings having been carried on at a very early period, I cannot but think their objections are without foundation, and that the boulders and other fragments have been filled in, either purposely, or by one of those "runs" so likely to occur during the excavation of wide spaces.

This, at all events, appears an easier hypothesis than that of a vein-chasm having stood open at the time of the spread of the boulder-drift.

operation since 1757; and that after 1787 they had been divided into two sets, comprising respectively those situated to the west and those to the east of the river. They are described as established on several veins, the chief of which runs from E.N.E. to W.S.W., with a width of from 6 to 10 fathoms, and generally divided into three ribs; the most remarkable of the secondary veins is, first, the "Magpie," running N.W. and S.E., 4 to 8 feet wide, and producing copper pyrites and also native copper in quartz; secondly, the "yellow ore vein," coursing from E.S.E. to W.N.W., varying from 18 to 20 inches in width, and affording copper pyrites in a gangue of quartz and killas; the third is the "copse north vein," which runs N. and S., is 8 to 24 inches wide, and contains the same minerals as the last; fourth, the "copse south vein," with a width of 18 to 36 inches, and similar ores. The two latter are supposed to form a junction with the principal lode on the S.W., where it was found to be accompanied by a parallel vein which appeared to be on the line of their prolongation.

Five adit levels had been driven at Cronebane, the deepest of which was opened in 1791; and several shafts had been sunk, although the deepest was not more than 36 fathoms.

At Connary, near the main road, the vein contained, at a short distance from the surface, a steel-grained galena, averaging about 25 per cent. of lead, and  $1\frac{1}{2}$  ounces of silver in the cwt. The gossan of the lode presented an ochrey substance, producing one half per cent. of silver and a little gold.

The massive yellow copper ore gave 5 or 6 per cent. of copper, and the pyritous ore from 1 to 10 per cent. From the latter, when smelted at Liverpool, a certain proportion of silver was extracted by liquation, which yielded 0.01146 of gold.

The quantities of ore raised between May 1788 and May 1791 were as follows:—

	1788.	1789.	1790.	Average produce of copper.
	Tons.	Tons.	Tons.	
Yellow copper ore -	116	262	563	8 per cent.
Pyritous ore - -	52	478 $\frac{1}{4}$	112 $\frac{3}{4}$	5 „
Roasted ore - -	24	22 $\frac{1}{2}$	47 $\frac{1}{2}$	9 „

The author of the notice was unable to obtain an account of the quantities raised at Ballymurtagh, a mine which had been worked long previous to Cronebane.

Mr. Weaver's description of these mines in his Memoir on the Geological Relations of the East of Ireland is well known. During the 24 years for which he was connected with Tigroney and Cronebane, the production of those mines was as follows:—

	Copper ore.	Copper.	Average produce.
	Tons. Cwts.	Tons. Cwts.	
In 12 years ending 1799 - - -	7,533 0	670 11	8 $\frac{2}{3}$ $\frac{5}{8}$
In 12 years ending 1811 - - -	19,342 13	1,046 10	5 $\frac{5}{12}$
Total - - -	26,875 13	1,717 1	6 $\frac{1}{3}$ $\frac{3}{8}$

At that time sulphur was extracted on the spot from the copper pyrites, by a process of distillation conducted in kilns containing 50 or 60 tons of ore, and fitted with close flues leading to a long brick receiver; the sulphate of copper formed during the decomposition being afterwards dissolved out and treated by cementation.

In 1840, and the two subsequent years, the interruption of the sulphur trade with Sicily obliged the English manufacturers to turn their attention to the iron pyrites of the Ovoca mines, an ore which from its granular texture admits of easy metallurgical treatment, although from its general impurity, and from the frequent presence of arsenical pyrites it is disadvantageously employed for particular purposes. Some attempts have been made to economize it on the spot, but have not hitherto given satisfaction, and although large quantities of the ore are still exported to England, almost the whole of it is applied to the production of sulphuric acid. For a year or two during which an active demand existed, a very great amount was exported from the Wicklow mines;\* and although the fluctuation of price has rendered it sometimes scarcely worth while to con-

\* In May 1840, Ballymurtagh was raising 1,200 tons, Ballygahan 150 to 200 tons, Cronebane and Tigroney 600 to 700 tons, and Connary 200 to 300 tons per month, or about 2,400 tons together.

tinue the workings, particularly in such portions of the veins as produce the more impure and therefore low-priced ore, the annual amount raised has of late been greatly increasing.\*

The importance of the produce of the Ovoca mines will best be appreciated from the following return, communicated by the Custom House authorities of Dublin, of the quantities of iron-pyrites (sulphur ore) and of copper ore, shipped at the ports of Wicklow and Arklow in each year from 1840 to 1852, both inclusive:—

Years.	Iron pyrites.			Copper ore.			Grand total of both ores.
	Wicklow.	Arklow.	Total.	Wicklow.	Arklow.	Total.	
Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1840	27,172	13,004	40,176	7,065	4,365	11,429	51,605
1841	40,823	36,565	77,388	1,764	3,376	5,140	82,528
1842	20,494	19,963	40,457	5,406	5,776	11,182	51,639
1843	19,995	19,191	39,186	4,292	4,545	8,837	48,023
1844	15,772	19,189	34,961	4,892	5,270	10,162	45,123
1845	9,573	29,445	39,018	4,854	5,042	9,896	48,914
1846	10,815	25,245	36,060	3,958	4,350	8,308	44,368
1847	10,619	29,889	40,508	1,919	2,886	4,805	45,313
1848	15,462	25,777	41,239	307	3,600	3,907	45,146
1849	19,103	26,524	45,627	142	3,800	3,942	49,569
1850	24,221	49,823	74,044	1,493	2,836	4,329	78,373
1851	29,399	73,039	102,438	41	2,023	2,064	104,502
1852	30,770	67,218	97,988	444	2,358	2,802	100,790
Totals	274,218	434,872	709,090	36,577	50,226	86,803	795,893

21 cwts. are allowed to each ton of ore.

\* It may here be remarked that a large proportion of pyrites is left unworked, in consequence of its being too much mingled with other substances to be available by the processes at present employed. The small quantity of sulphur (as such) which can readily be extracted from the ore is evident on the following consideration: an average pile of the sulphur ore may contain about 75 per cent. of pure iron pyrites, and from 100 tons of ore we shall therefore only have 75 tons of useful mineral. But iron pyrites is a bisulphuret of iron, or contains two equivalents of sulphur combined with one equivalent of iron; and when it is heated to redness in a close vessel it gives off, not the whole of its sulphur, but less than half; and the remainder enters into a new combination with iron, called magnetic pyrites, and represented by the chemical formula  $\text{Fe} + 6 \text{Fe}_2$ .

Casting a retrospective glance over the remarkable series of ore-deposits detailed above, we observe that the metalliferous contents are disposed in several groups of straight lines presenting, with a singular degree of parallelism, most of the characteristics of bedded or stratified masses, such as their conformability to the beds of the slatey rock of the country, their freedom from vein-stone, from "vugs," and from crystallized minerals, their laminated structure, and the gradual blending, in most cases, of their ores with the adjoining strata. Yet the mode in which, when closely followed, they appear to cut *across the strike* of certain beds, and the existence of such phenomena as the "heave" described in Ballygahan mine, on the west of the engine shaft, the T-shaped fissures in Tigroney, and lastly, a comparison of these with the facts disclosed in the mines of the Paris mountain in Anglesey, induce the belief that they must be regarded as lodes or true metalliferous veins of a peculiar order. The copper lodes, lying, as will be remembered, on the south of the "sulphur course," monopolize all the characters here cited, and we might be led to the conclusion that they alone are to be viewed in this light, were it not a too improbable assumption, that they should have made their appearance in lines so nearly coinciding with previous sedimentary deposits of pyrites, which both in mode of occurrence and in mineral contents are in places almost undistinguishable from them; and hence we are necessitated to apply to all the same attempts at explanation.

Under such circumstances it is not uninteresting to take these features, and adding to them the characters of the slatey, the hornblendic, and the felspathic rocks of this zone of country, as well as the association of certain minerals found together, to compare these veins with some of the irregular ore deposits (*Lager Germ.*, *Amas aplatis Fr.*) which occur on the continent of Europe. At Berggrieshübel in Saxony, deposits of this order, containing magnetic iron, copper ores, zinc blende, galena, with garnet, quartz, &c., follow very regularly the strike and dip of

---

Thus the 75 tons above mentioned, containing 53·3 per cent. of sulphur, and giving off less than half of that amount, would yield only about 17 tons of actual sulphur, though the rest may be obtained from the magnetic pyrites by the process of burning, in which it unites with oxygen, and forms sulphurous acid.

the environing clay-slates, the latter varying from  $15^{\circ}$  to  $90^{\circ}$  to the north-east. Near the surface were found in place of the above, red and brown ores of iron, with barytes.

But more remarkable, from the large quantities of ore extracted from them, and the long period during which they have been wrought, are some of the ore-masses of Scandinavia. At Arendal the "country" consists of gneiss, passing occasionally to hornblende or to mica slate; and a number of more or less parallel bed-like masses run throughout a narrow zone, but for some 12 miles in length, parallel to the lamination of those rocks. The minerals which they present are chiefly magnetic iron, associated with hornblende, granular augite, garnets, epidote, &c., and occur in a kind of vein with a thickness of from 6 to 60 feet, without any distinct wall to separate it from the rock, and often of a laminated structure corresponding to that of the gneiss.

At the mines of Dannemora, celebrated for the excellent quality of the iron produced from its magnetic ore, analogous features are again presented: that ore is associated intimately with chlorite, and more or less with pyrites, zinc blende, galena, quartz, garnet, hornblende, &c., the deposit being bounded in some parts by a gray limestone, and in part by a porphyritic rock of silicious felspar, or petrosilex, locally termed *hällefinta*, not unlike the above-mentioned masses which occur near the lodes of the Ovoca.

Fahlun, during five centuries the source of vast quantities of copper, is a deposit of very similar character, situated in a gneiss country, but divided from that rock by a zone of mica-slate and strips of very contorted talcose-slates. The copper pyrites, which is the chief object of the exploitation, is accompanied by magnetic iron ore, iron pyrites, zinc blende, galena, quartz, and chlorite, the metallic sulphides containing a small proportion of silver and gold. Although in form this metalliferous mass differs more than any of the above from the pyrites lodes of Wicklow, and has been worked down to a depth of 200 fathoms without presenting any of the characters of a lode, it is crossed by a great number of true metalliferous veins of small dimensions, bearing copper pyrites almost free from admixture with iron pyrites, and somewhat akin, it would seem, to the copper lodes described in Ballygahan and Tigroney mines.

We may thus note a certain degree of affinity between the localities described in this paper and the beds and masses of analogous ores occurring in the gneiss and ancient slates of Sweden. We have not in Ireland, it is true, that variety of silicate minerals, nor the combinations of cerium and other rare metals which characterize the Scandinavian deposits, but the association of copper pyrites with magnetic iron, with chlorite, and large masses of iron pyrites, cannot but suggest a comparison which tends to raise our expectation of the future prospects of the Wicklow mines.

Whilst observing the subject in this light, it may not be overlooked that the upper part of the beds explored by the miner at Ballymurtagh varies materially from that at Cronebane and Connary; at the former, the principal deposit, iron pyrites, occurs immediately beneath the gossan, whilst at the latter the following remarkable sequence of ores presents itself:—

Surface, gossan	- Brown iron ore with a little silver, 8 feet thick.
18 fathoms	{ Black copper ore, with occasional portions of galena,
25     ,,	zinc blende, and antimony glance.
35     ,,	- Copper glance, with black copper ore.
45     ,,	{ Iron pyrites, with occasional ribs of copper pyrites,
84     ,,	below which the example of Ballymurtagh would lead us to expect copper pyrites.

The difference thus observed results, no doubt, in a great measure, from the western bank of the Ovoca, exhibiting a deeper part of the metalliferous plane, which at an epoch posterior to its solidification has been so affected by dislocation and denudation, as to present that deeper part almost at the same level with the higher part on the eastern bank of the river.

In the plate (III.) let the line N K O represent the intersection of the surface of the ground by the metalliferous vein at a period before the disturbances which caused the heave, and let E F G H be a part of the plane of dislocation, which we have above described as now separating the extremities of the lodes by about 1,000 feet: \* the line of intersection of the two planes,

\* The total amount of heave may probably be due to several distinct dislocations; but, since the result is the same, we may, to simplify the subject, take their sum and consider them as one major dislocation.

i.e., of the lode and the dislocator, before any change of position has taken place, will be K G. But the heave has been effected by the depression of the whole mass K O D G, in consequence of which the point K of the lode has slipped down to a point M, and the intersection of the eastern part of the lode with the dislocation is M H, leaving the horizontal distance G H, or at the surface L M, between the severed portions. Since the epoch of disturbance the portion N K A L has been abraded, and A L the modern surface along the line of outcrop, although at considerable depth below the original "back" of the lode, nearly corresponds in elevation with the surface M C, the upper portions of which are evidently much more nearly the upper part of the metalliferous deposit as it originally existed.

In the figure the outcrop of the main vein is represented by a double line, its position and that of the copper lodes in the transverse section C D by dotted bands. The principal shafts and galleries of the mines are also represented, the number which is attached to some of the galleries showing the depth in fathoms below the adit level. The workings of Ballygahan mine are given in dotted lines, as supposed to be seen *through* the cross course or dislocating plane. A part of the workings thus shown are upon the pyrites course, and a part on the copper lodes, whilst most of the shafts are sunk perpendicularly through the slaty rock, intersecting the ore deposits only at certain points. These minutiae can, of course, only be represented by a plan and section on a larger scale, such as that to which I have before referred. The object of the diagram is simply to show, first, how a large horizontal displacement is probably the effect of a more or less vertical depression of one division of the rock mass with regard to the other; and secondly, how the eastern division, remarkable in its upper part for a collocation of minerals peculiar in itself, and differing from anything on the western side of the river, is much nearer than the latter to the pristine surface of the land. The shafts and levels are introduced as guides to the locality, and as showing the depth and horizontal extent through which the excavations have been carried on within the particular district referred to.

It will readily be perceived, when we observe the considerable tract of ground offering indications of ore, but lying as yet

unwrought, that any ray of light brought to bear on the illustration of this succession of different minerals at increasing depth, may involve consequences of the highest interest and importance in a commercial point of view. The mines which we have described as in active operation occupy a length of little more than 2 miles,\* whilst there remains on the S.W., between Ballymurtagh and the granitic rocks of the mountain mass of Croghan Kinshela, a space of above five miles in length, throughout which the same or analogous deposits of ore have been proved to exist at intervals. As adverted to in p. 371, appearances of considerable promise have been met with at Ballymoneen, Knocknamohill, Ballycoog, and Moneyteige; the two latter being in the Carysfort royalty, and adjoining Croghan. From various causes no efficient exploration has yet been made in these setts; and it still remains to be proved, whether, as in the Ovoca mines, vast masses of iron pyrites will be found beneath the more mixed ores which occupy the surface, a conclusion very probable, but rendered uncertain by the varying character of the adjacent slate work.

We have seen on how large a scale the pyrites is now exported from the mines of Ovoca, and cannot doubt that at the rate of 100,000 tons a year this extraction must go far toward exhausting their stores at no distant period. How important, even in these days of peace, are such supplies of "sulphur ore" to our great manufactures; and how would that importance be increased should our intercourse with Sicily be interrupted by war or other causes! Evident enough it is, that these peculiar riches of the Wicklow Hills have become almost indispensable alike to English and to Irish industry; to the one, in their application, and to the other, in their extraction; and that for the continuance of a bond so desirable, and a boon so mutually useful, further efforts on the part of the geologist and miner will be needed, which will merit an extended, nay, even a national interest.

At a few other spots in the county of Wicklow the slaty rocks contain small quantities of metallic minerals: thus, on the right-hand of the road, between Ballinglen and Sandyford, large masses of gossan mark the presence of a lode from which

---

\* See the Map of the district, Pl. II., appended to this Memoir.

lead ore was raised about a century since, but the cultivation of all the land around it, and the filling of the shafts, render it impossible to trace its course. At Ballinalea, on the high road from Rathdrum to Dublin, a little copper pyrites has been seen in a powerful lode of quartz, which contains numerous rhombohedral cavities, partly occupied by brown peroxide of iron, and may therefore probably be due to the decomposition of carbonate of iron. A shaft of inconsiderable depth was sunk at this spot, but without success.

At Ballintemple, near the spot where the pyrites veins cross the valley of the Aughrim river, and on the south side of the stream, a small lode of lead ore courses nearly at right angles to the strike of the slate beds, and in the small workings which have been opened upon it has exhibited here and there a rib of galena, varying from 1 to 8 inches in width, accompanied by *flucan* or soft argillaceous matter. In a neighbouring valley in Clonwilliam a lead lode has also been seen, but not hitherto opened on.

Proceeding southward into the county of Wexford we find that very few localities have presented favourable indications of the presence of metallic minerals. A few years since, however, a mine of considerable promise was opened at Caime, a short distance to the west of the town of Enniscorthy. The dark grey clay slate of the country, in its usual strike of N.E. and S.W., is pierced by a nearly vertical lode, coursing  $15^{\circ}$  south of east, and splitting on the west into two branches. The upper portions of the lode yielded a few tons of copper ore, but argentiferous galena was the chief product of the mine, and the point of juncture of the two branch veins above-mentioned was enriched by an accumulation of galena, of some 12 feet in width, down to the 47 fathom level, but dwindling away thence to the 67 fathom level, where it was not more than 5 feet wide.

From this rich deposit the veins run to no great ascertained distance, with a width of about 3 feet, a small part of which only consists of ore, the rest being composed principally of threads of quartz. The general character of the veins or "strings," which vary from  $\frac{1}{10}$  of an inch to 3 or 4 inches in width exhibits a riband structure, the outer members or plates (those attached to the walls) being sparry iron, and the inner, galena or zinc-blende, or both together: thus,

Sparry iron,  
Galena and zinc-blende,  
Sparry iron.

Calcareous spar often occurs with the sparry iron, and the decomposition of the zinc blende, which is sometimes mixed with it in exceedingly minute particles, tinges the exterior of all the fragments on the surface with a dark brown stain.

The dressed ore contained about 75 per cent. of lead, and 15 ounces of silver to the ton of lead.

A little carbonate of lead is seen in the fragments from the upper part of the lode.

This mine is situated at a considerable distance from all surface evidence of massive or igneous rock, being nearly 4 miles to the E. of the granite, and 3 miles W. of the bands of greenstone which strike across the country from the river Suir on the S.W. to near Gorey on the N.E. One of its most remarkable features is the irregularity of its course and angle of inclination, which gave to the workings, although they were of no very great extent, a most complicated appearance. Thus, from the 37 fathom level the vein dropped perpendicularly to the 47, and was then 30 feet wide, worked in one excavation.

The operations were checked on the W. by a *slide* or dislocating plane, which holds water up to the surface, and beyond which it is very probable that the lodes may yet be found. In 1846 the mine had for some time been abandoned, and a large opencast or pit was all that remained to be seen ; it was full of water, and had been excavated in this manner in consequence of the confused occurrence of strings of ore amid old workings.

More remarkable in many respects is the Barristown lead mine, in the extreme S. of Wexford, a place worked evidently at a very early period ; even according to the common traditions of the country, by the Danes. The lode had been followed only 12 fathoms deep ; and since on examination a few years ago, it was found that ore was visible at that depth, it was assumed that the old miners had been baffled by water, although it afterwards proved that the total interruption of the lode by a "slide" had been the cause of its abandonment.

The mine, which had been for a few years past idle, was about 1846 attracting considerable attention, from the un-

usually large proportion of silver, 60 to 70 ounces of silver per ton of lead, contained in its ores. In a geological and mining point of view it is also interesting from its low angle of inclination, and the peculiar heaves by which the northern or principal of the three lodes is frequently dislocated.

The clay slate of the neighbourhood dips at an angle of  $45^{\circ}$  S. by E. and S.S.E., whilst the vein courses about E.S.E. and W.N.W. with an inclination to the north, which is very variable, although averaging  $40^{\circ}$  to  $50^{\circ}$ . It is generally about 3 feet wide, and composed principally of ribs of quartz with sparry iron ore, galena, and zinc blende, the sparry iron adhering to the walls or sides, and often crystallized towards the interior, whilst the other ores occupy the central part. Parallel in strike, but dipping oppositely to the lode, are several slides or faults, generally accompanied by an inch or two of *flucan* or soft clay, which dislocate the lode, and that too, it would appear, always in an opposite direction from what it would be expected, according to the law which commonly holds good in such cases.

Thus, in the old shallow workings east of the "footway shaft" the lode dips at the low angle of  $22^{\circ}$  N.E. by N., whilst the slide falls nearly opposite to it at  $25^{\circ}$  to  $40^{\circ}$  W., and the lode is heaved 6 or 8 feet on the side of the *acute angle*, whilst it would ordinarily be looked for on the side of the obtuse angle formed between the intersecting planes. Phenomena of a similar character are seen also in the "Danes' Shaft," close below the 18 fathom level, on the west of the "Flat-rod Shaft," and elsewhere; whilst after the lode in its descent has several times been thus dislocated reversely, it abuts at last against the face of a set of beds of black slate-rock, which appear to act a very similar part to the "slides," with the exception that no farther trace of the lode has yet been met with.

Since examining these heaves underground, I have had to regret that no detailed section of the mine at that time existed, and that I was, by the early abandonment of the mine, disappointed in the expectation of examining them more minutely on a future visit; it thus becomes impossible closely to inquire into the nature of a phenomenon, highly interesting both to the miner and the geologist, and I must rest contented with pointing out that there exists in the Barristown mine a succession

of reversed faults similar to those which we occasionally observe in coal measures, and to those on a small scale described by Messrs. Prestwich and Morris, Quart. Geol. Soc. vol. ii. p. 402, and by Mr. De la Condamine, in the same work, vol. viii. p. 193.

In 1846 a steam-engine, with cylinder of 30 inches diameter, was employed to pump at the principal shaft to a depth of 30 fathoms, and to work horizontal rods in the western shafts to 18 fathoms, besides driving a crushing-machine for the dressing of the ores.

#### *Stream Works or Alluvial Deposits.*

From time immemorial, ornaments and insignia of solid gold have been found in Ireland, and men have wondered whence came so great an abundance of the most precious metals among the early inhabitants of the country. That it could have been picked up from amid the sand, gravel, and clay of the beds of streams and the adjoining alluvial cover, was a supposition that seems to have met with but few supporters; yet incredulity was forced into belief, when sources of this kind suddenly yielded a supply of gold in the county of Wicklow at the close of the last century; and now at length the astounding successive discoveries of auriferous detritus in Siberia, California, and Australia, have rendered that mode of occurrence familiar to us all.

It is, however, in no small degree remarkable how previous experiences are gradually forgotten, analogous histories neglected, and a great cry of novelty raised upon a phenomenon of an order which ought to have been well and generally known. Whilst tongue and press during the last five years reiterated expressions of astonishment that gold should be found in lumps near the surface of the earth, the recent scenes in Wicklow were overlooked, and the almost universality of the occurrence of alluvial gold appears to have been lost from sight by all but a few geologists and miners. This is no place for entering at large into the question, but it may be noted, that a large portion of the gold current among the ancients was derived, according to the testimony of various historians and geographers, from such sources. The author of the Book of Job, clearly alluding to auriferous sands, mentions "that the earth

has dust of gold :" and Herodotus, Athenæus, Strabo, and Pliny, all bear evidence of the wide diffusion of the metal under the same circumstances.

In fact, we can scarcely point to any regions watered by streams flowing from primary mountains in which more or less gold has not been, or is not even yet to be, found. Witness, as a few known examples, our Cornish stream-works, Lead Hills in Scotland, the valleys of the Rhine, Danube, Drave, Nile, and numerous rivers in Bohemia, Transylvania, and Spain, from many of which gold is still obtained in small quantities by the streaming processes. But in all the old and well known countries, the simple operation of picking out the richer portions of these deposits was commenced thousands of years ago, and very few spots are left rich enough to reward the labour of the seeker ; it is therefore, in a general way, only in lands new to civilization, and where the existence of gold has been from particular circumstances undiscovered by the natives, that those great supplies can be expected, which of late have given so great an impetus to communication and commerce.

In the year 1795 it transpired that lumps of pure gold had been picked up in a valley on the flank of the mountain called Croghan Kinshela, in the southern part of the county of Wicklow. The discovery, which was purely accidental, was kept a secret for some months, but no sooner was it made known than crowds of the country people, throwing aside their ordinary occupations, rushed to the spot to secure a share in so promising a harvest. Some hundreds of gold-diggers (to adopt the new-world phrase) were soon employed along the stream, and during about six weeks appropriated to themselves a considerable amount of pickings. After that time the Government, fortified by a special Act of Parliament, established a more systematic *streaming*, under the direction of Messrs. Mills, King, and Weaver, and up to the outbreak of the rebellion in May 1798, continued to make the operations remunerative. During that unfortunate period the works were totally destroyed, and not till the year 1801 were they again brought into activity. It was now that the directors, reasoning on the evidence obtained in various countries, that alluvial gold has been derived from veins of that metal situated at no great distance up the stream, commenced the driving of a level or gallery into

Croghan, and the cutting of a long series of trenches in various directions, from the surface down to the solid rock, for the purpose of discovering the lodes, from which it was argued that the gold had travelled. The reasons for carrying out these operations are fully given in the detailed paper above alluded to, by Mr. Weaver, in the Transactions of the Geological Society of London. But the level was carried for a great distance (about 178 fathoms) into the heart of the mountain, and the costeaning trenches were dug for thousands of fathoms in length, yet not a particle of gold *in situ* ever rewarded this patient labour. Veins of quartz, numerous yet irregular, were indeed discovered, but they appear to have been almost totally destitute of metallic contents.

Meanwhile the stream-works, or operations in the alluvial deposit, were perseveringly continued for some years, but the "crop" or best part had already been picked by the country people, and after a while the Government was advised to abandon the undertaking, having raised above 944 ounces of gold, the ingots of which were from  $21\frac{3}{8}$  to  $21\frac{7}{8}$  carats fine, the alloy being silver, and the total value at the time being 3,675*l.*

Since that period it has been attempted to work the same deposits by a company, but without success, partly, it may be presumed, from the rarity of the precious metal, and partly from the difficulty experienced in all gold-streaming or gold-digging regions of obtaining from the workmen the full produce of their labours. There appears to be a something so magical in the sight and feel of native gold,—so dangerous a property of ready convertibility into all the requisites of life, that in passing through the hands of a labourer it cannot be a matter of surprise that the more tangible pieces stick by the way, and are not forthcoming among the assets of the company. I have heard in Transylvania striking anecdotes of the demoralization produced among paid workmen by the handling of the precious metals in a state requiring little or no farther operation for adapting them to pass current; very similar accounts have reached us from South America; and it remains to be seen whether companies formed for the working of stream-gold in Australia will be successful in securing their expected profits.

Of late years, only a few of the neighbouring peasants have from time to time been engaged in gold-washing, and it is very

difficult to form a fair estimate of the remuneration yielded them by their labour.

The more important of the auriferous localities are situated in the valleys which branch off from the northern side of Croghan Kinshela, and through which the waters flow to the Daragh or Aughrim river. Two of these streams unite at a point not far from the well-known Wooden Bridge, and form the so-called Gold mines river. The vestiges of the gold-washers are recognized in the confused heaps of stone, many of them overgrown with sod, which occur scattered along the bank of the streams. The sides of the hills, well-clothed with wood and grass as you ascend from the Wooden Bridge, fall more steeply to the stream, and present a wilder aspect on a nearer approach to Croghan. The clay slate-rock of the country is, however, seen only occasionally, except in the bed of the brook, where, in the cavities amongst its rough, up-turned, and broken edges, many of the pepites or nuggets of gold were found. Higher up the valley a considerable cover of detritus overlies the solid rock, attaining in some places a thickness of 50 feet, and increases to a great extent the difficulty of working with advantage; since the precious metal was only found in a thin bed at the bottom of this mass of useless sand and soil. As usual with such deposits of local detritus, its variation in thickness was very great even in a limited area; and thus, just as the Siberian, Californian, or Australian gold-digger may expect, the treasure was in some places to be attained close to the surface, in others only beneath a great thickness of valueless material more or less difficult to pierce through and remove.

The gold occurred disseminated throughout an irregular bed composed of clay, sand, and fragments of rock more or less rounded; the particles were generally minute scales, but large solid lumps were found from time to time, the heaviest of which weighed 22 ounces. A great number of other minerals accompanied the gold, and were described by Mr. Weaver after a careful examination of the concentrated sand; among them magnetic iron ore, sometimes in masses of half a hundredweight, was the most frequent, titaniferous iron, specular, red, and brown iron ores, iron pyrites, tin ore, and its curious associate wolfram, a manganese ore, garnets, quartz, and chlorite were also abundant. Some of the specimens exhibited the gold in

association with wolfram, brown iron ore, and with quartz. To the above list Mr. Mallet has added (*Tran. Geol. Soc., Dublin, Vol. iv., p. 271,*) several others from his own observation; at the head of the new species stands platinum, and then succeed the ores, galena, copper pyrites, and molybdenite, and the gems sapphire, topaz, zircon, and spinelle.

It is very interesting to trace this association of substances which have been found together in all the gold-fields of the earth wherever they have been accurately described. Dufrénoy has published in the *Annales des Mines* the results of his examination of concentrated sands from California and New Granada, and compared them with the products of the Uralian washings, and of our tin stream-works in Cornwall. In these and many other places which might be referred to, magnetic iron is the principal ingredient, in the Ural 23 per cent., in California 59 per cent.: titaniferous iron sand is also present in large proportion, and in all of them more or less of the same gems have been discovered. Some of the more frequent, next to the varieties of quartz, are sapphire, zircon, spinel, and garnets. The American sands—both of California and New Granada—contain the largest proportion of white zircon, whilst in the Ural it is surpassed by chrysoberyll of a yellowish green colour, and chatoyant play of light, forming as much as 10 per cent. of the entire body of the concentrated sand. Spinelle has not been observed in either of these, although common in the tin-streams of Cornwall and of Pyriac in France.

The most important companion of the gold is, however, according to Mr. Mallet, the tin-stone; and from having been able to detect but little of it on the spot, I was much surprised at the announcement that he had obtained  $3\frac{1}{2}$  lbs. of stream-tin from about 150 lbs. of the sand, a ratio of productiveness which throws into the shade all the richest stream-works ever found in Cornwall or on the continent. Could it only be proved to be distributed in the same quantity over any considerable area, the gold valleys might again become tenanted to good purpose, and it would then be very strange if some clue were not obtained to the original depositories of this valuable ore, hitherto sought for without the least success.

Having been desirous (at the time these sheets are passing

through the press) of ascertaining from Mr. Weaver whether he had ever found the tin-ore in a sufficient ratio to render it worth extraction, and also whether any approximate percentage had been calculated for the gold in relation to the total of the material washed, he was good enough to give me all the particulars obtained, from which it appeared that at the time of the activity of the works no sufficient quantity of tin-ore was procurable to render it economically valuable, and that from the great variation no satisfactory estimate was made of the quantity of material from which a unit of gold was obtainable. With respect to the occurrence of tin-stone, he has to complain with reason, that after his repeatedly placing on record that it had been recognized and proved by him, the subject has been brought forward as a new one, and disputed or said to be established, by inquirers to whom the previous observations ought to have been thoroughly known. And here I cannot but express the pleasure which I felt in observing the spirit and interest with which so aged a veteran entered into the subject, and discussed it for hours. Mr. Weaver was a hearer of the great Werner at Freiberg in the year 1790, and a fellow-student with an illustrious trio, of whom one only now remains to us, Von Humboldt, Von Buch, and Freiesleben, late the chief officer of the Saxon mines. The desirable "*mens sana in corpore sano*," strengthened by a cultivated taste for scientific inquiry, and by a life of useful activity, has distinguished these patriarchs of geological science even when they have thus passed their eightieth year.

Besides the principal auriferous valleys on the north side of Croghan, several others have been closely examined, and some of them were found to yield gold; in Coolbawn a piece weighing  $2\frac{1}{2}$  ounces was discovered, and a little glen which intersects Ballintemple has been lately worked on a small scale with some success for several years. The same minerals, which I have above enumerated, were generally associated, and it is not without interest to observe that many of them are identical with those exhibited in the lodes at Ballycoog and Moneyteige, as described above,\* and, moreover, that from the form of the hills it would be very possible to derive the spread of the auriferous drift from that strongly marked ridge. Indeed, I am inclined

to infer that it was the back or upper part of these lodes, the waste of which furnished the greater part of the alluvial metallic substances found in the valleys below,—and amongst them of the gold. Not only is this opinion supported by the presence in the lodes of so many of the same minerals, but by the very generally observed phenomenon of the upper part of lodes being much richer in gold than the deeper portions, whilst it is well known to the miner, that after an auriferous alluvium has in many cases been followed up to what appears without doubt to be its parent vein, only minute traces—or perhaps none at all—have been discovered in that part of the original deposit to which the entire surface has now by natural causes been ground down.

Gold has been found also in a totally distinct locality, about 7 miles from the above, at the foot of a mountain called Croghan Moira, whose conical form attracts the eye of the geologist or the sketcher from a great distance. On the eastern side at Ballycreen, and on the western, at Ballynacapogue, small quantities only were found, associated again with many of the same minerals.

Speculations have been raised as to whether the auriferous alluvium is distributed over a large area in the country. It is tolerably clear that it was not brought into its present position by the now existing rivulets, but still it was evidently placed there after the surface of the land had acquired something like its present outline. It therefore seems to follow that the same rule which has been observed in the gulleys of Australia will also hold good in Wicklow, viz. that the drift and gold are both most abundant at or near the course of the stream, and become thinner and poorer as they ascend towards the flank of the hills; hence it would not appear probable that any large deposits exist in Wicklow, although there may possibly be many glens and valleys where some small proportion of the precious metal lies as yet undisturbed.

With the technical processes of streaming we have here no concern, since none but the simplest and most obvious have yet been employed in this district; and unless vast quantities of the material to be washed could be brought into play, it would not be feasible to employ such machines as those used in Siberia, by which sands are treated, so poor that they contain only *one millionth* part of gold.

In conclusion, let me remind the reader that only a few facts in the geology of Wicklow have been adverted to in the foregoing pages. Fully to appreciate the bearing and relation of the numerous questions which suggest themselves in any particular area, the examination of a large region must first be undertaken by the investigator; and any opinion on theoretical points, which is founded on a partial survey, must remain open to the corrections of a more widely extended knowledge. The miner has to deal, however, chiefly with one department of geology, the *geognostical* character and position of the rocks,—with their actual condition, in fact, as they now exist. It is only in a secondary degree,—although sometimes in matters of high importance, that he need to occupy himself with the study of the relative age of deposits or eruptions. For this reason, an isolated memoir like the above may always be serviceable in recording observed facts, whose truth is independent of some of those considerations with respect to geological antiquity which interest, probably, the larger class of readers, but which necessitate the comparison of observations collected from a very extensive province.

The maps appended to the memoir, drawn on the scale of an inch to the mile, and coloured geologically, will serve to illustrate much of what has been described among the general features of the Wicklow mining districts. It has been thought the more desirable to add them, since both of the tracts represented, although differing from one another *toto cælo*, offer very numerous points for examination and study within an area at the same time moderate in extent and accessible.

Plate I. includes almost the whole of the lodes described in the first part of the paper, with many of the granite viens mentioned at p. 351, and also the interesting appearances at the junction of the granite and mica-slate, which have been commented on by Sir H. De la Beche in his "Geological Observer."\* It is, moreover, a district which, although very laborious to examine in detail, as may be inferred from the inserted heights above the sea level, possesses additional inducements in the succession of striking scenes presented by its deeply cut valleys and variously outlined mountains.

---

\* The Geological Observer, 2d edition, pp. 562 and 574.

Plate II. embraces a country of a less picturesque character, although from the weather-beaten jagged summit of Croghan Kinshela, 1,987 feet above the sea, to the wooded banks and smooth meadows of the Ovoca, the scenery offers a great diversity. The index map of the country, which has been published by the Survey as a geological map, being on a scale of but one inch to the mile, can necessarily give only a general view of the geological features; the six-inch map, or townlands survey, on which the field observations were made, has been deemed too large for publication; but the details of that important part of it occupied by the mines, have been, as already noticed, published in a separate sheet on a far larger scale.\*

Plate II. will however partly supply the want of a larger map in offering a view of the geological relations of the lodes and the structure of the neighbouring country. Its chief point of difference from the published index map is, that a distinct colour is given to a group of felspathic rocks, which throughout this and the neighbouring counties on the south play a prominent part. These masses, of which the Bell Rock at Lower Ballygahan, beetling above the main road, may be taken as a type, are composed of what has sometimes been termed petrosilex, or compact felspar, but may conveniently be termed felstone;† if by that name we understand a compound of felspar with free silica, mostly compact, but sometimes exhibiting minute crystals of felspar imbedded in a homogeneous paste. This kind of rock, which may readily be distinguished from quartz rock, by its weathering on the surface, and by its fusibility in thin splinters before the blow-pipe, occurs in a great variety of pale tints: it sometimes forms huge irregular bosses, in which no planes of separation, except joints like those of igneous rocks, are observable; at other times it is distinctly stratified, and often by the increased admixture of other detrital matter with its felspathic constituents, passes by so gradual a transition to the state of the argillaceous slates of the neighbourhood, that the line of demar-

\* Plan and sections of the Ovoca mines, on a scale of 18 inches to a mile, published by the Geological Survey of Ireland.

† See Sedgwick's Letters to Wordsworth on the Geology of the Lake District of Cumberland and Westmoreland; and for the production of a similar rock by metamorphic action, Breithaupt, Die Paragenesis der Mineralien, p. 51. Freiberg. 1849.

cation drawn between the two is of a very arbitrary kind. Wherever represented in this map it appears to be what geologists term contemporaneous with the slates, i.e., to have been accumulated in thick or thin beds, and more or less intermingled with ordinary detritus, alternately with the slatey strata, possibly too, metamorphosed since its original deposition; but closely related as it is to dykes or intrusive veins, seen in some parts of the sea coast, it is a species of rock which may owe its presence to distinct modes of action, and may thus involve consequences requiring special study in given localities.

The geology of these regions at large will be described by the Director of the Geological Survey of Ireland, Mr. J. Beete Jukes; and the objects of this paper will have been attained, if it add a few facts to the stores of our knowledge of metalliferous districts, and illustrate the interest of localities not less deserving the attention of the capitalist than of every friend of the country, as developing the resources of the land, and fostering by the most legitimate means the prosperity of the people.



## I N D E X.

---

- AGRICOLA, mention of cupreous waters, 385.  
Arendal, mines of, 393.  
Ballinalea, copper lode at, 397.  
Ballycoog, lodes of, 371, 396, 405.  
Ballycorus, mine of, 365.  
Ballygahan mine, 376.  
Ballymoneen, lodes of, 396.  
Ballymurtagh mine, 372.  
Barristown lead mine, 398.  
Berg-gieshübel, irregular deposits of, 392.  
Brown on the copper mines of Hungary, 385.  
Caimé lead mine, 397.  
Carysfort mines, v. Moneyteige.  
Cement, copper, 385.  
Connary, 382.  
Copper mines of Ballymurtagh, 372.  
— Ballygahan, 376.  
— Tigroney and Cronebane, 378.  
— ores of Upper Cronebane, 381.  
— Connary, 383.  
— precipitated from mine water, 385.  
— native, in Connary, 384.  
— ores of Scandinavia, 393.  
— returns of the, of Wicklow, 391.  
Croghan, Kinshela mountain, 370, 396, 401, 403.  
Croghan Moira, gold found near, 406.  
Cronebane, mine of, 378.  
Dalkey, lead lodes of, 366.  
De la Beche, on the Wicklow granite, 407.  
Diggings, gold, 401.  
Dufrénoy on gold stream works, 404.  
Exploitation, or working of Ballymurtagh, 374.  
— Ballygahan, 378.  
Fahlun, copper mines of, 393.  
Faults or dislocations of the Ovoca, 394; Barristown, 399.  
— reverse, 399.  
Felstone, a felspathic rock, 370, 408.  
Fissures, Wm. Hopkins on vein, 368.  
— cross, in a lead lode, 357.  
— origin of vein, 369.  
Frattegiano on copper in mine waters in Hungary, 385.  
Galena, argentiferous of Luganure, 354, 357.  
— Glenmalure, 360.  
— at Dalkey, 366; at Connary, 382.  
— of Ballintemple, 397; of Caimé, 397.  
— highly argentiferous, of Barristown, 399.  
— found with the gold, 404.  
Geological Survey, plan published by, 377.  
— maps of the, 368, 408.  
Glendalough, mineral veins of, 358.  
Glenmalure, mines of, 360.  
Gold of Wicklow, 400, 406.  
— wide distribution of, 401.  
Gossan, at Ballymurtagh, 373.  
— argentiferous, of Cronebane, 380.  
— near Sandyford, 396.  
Granite, of Wicklow, 350.  
— lead mines in the, 353.  
— veins, 351; their origin, 352.  
Heave, or dislocation of the Ovoca lodes, 394.  
— in Ballygahan mine, 376.  
— at Barristown, 399.  
Henry, Rev. Wm., on cupreous water at Ballymurtagh, 386.  
Herrengrund, cupreous waters described by Brown, 385.  
— present mode of precipitating copper at, 387.  
Hodgson, Mr., of Ballyraine, his mines, 353, 360, 374, 376.  
Hopkins, Wm., on vein fissures, 368.  
Hungary, cupreous waters of mines in, 385.  
Joints, in the granite, 369.  
Journal des Mines, description of the Ovoca mines, 388.  
Iron ores, of Glendalough, 358.  
— magnetic, of Moneyteige, 371.  
— of, in auriferous sands, 404.  
Iron pyrites, of Ballymurtagh, 372.  
— Ballygahan, 376.  
— Tigroney and Cronebane, 378.  
— Connary, 384.  
— ores, of Dannemora, 393.  
Knocknamohill, lodes of, 371, 396.

- Lead lode in Ballintemple, 397.  
 —— mines of the granite district, 352.  
 —— Caimé, 307.  
 —— Barristown, 398.
- Lead ore at Connary, 389.
- Lodes in the granite district, 353.  
 —— granite, their structure, 355, 357, 358, 363.  
 —— their directions, 367.  
 —— in the slate district, 371, 392.  
 —— cross, or T's, 373, 379.  
 —— of Ballintemple, 397.  
 —— Caimé, in Wexford, 397.  
 —— Barristown, 398.  
 —— Ballinalea, 397.
- Mallet on the minerals of the Wicklow stream works, 404.
- Machinery employed at the mines, 356, 358, 376, 378, 382, 385, 400.
- Mica, its pseudomorphous character, 352.
- Mica-slate, lead lode productive in, 360.  
 —— appearance of interstratification with granite, 361.
- Mica, vein of, 352, 362.
- Minerals, succession of, in some of the Ovoca mines, 394.  
 —— groups of, in Scandinavian mines, 393.  
 —— of the lodes in granite, 352, 354, 357, 359.  
 —— of the stream works in Wicklow, 403.
- Mines of the granite district, 351.  
 —— Luganure, 353.  
 —— Glenmalure, 360.  
 —— Lough Dan, 364.  
 —— Ballycorus, 365.  
 —— the slate district, 370.  
 —— Ballymurtagh, 372.  
 —— Ballygahan, 376.  
 —— Tigroney and Cronebane, 378.  
 —— Connary, 382.  
 —— Herrengrund, 385, 387.  
 —— Scandinavia, 393.  
 —— Caimé, 397.  
 —— Barristown, 398.
- Moneyteige, lodes of, 371, 396, 405.
- Ovoca, appearance of the vale of, 371.  
 —— mines of the, 372.  
 —— plan of the mines of the, 377.  
 —— history of the mines of, 388.  
 —— dislocation in the vale of, 394.
- Ow river, lead lode in the, 364.
- Produce of the mines, 358, 374, 382, 389, 391.  
 —— precipitation from mine waters, 386, 387.  
 —— gold stream works of Wicklow, 402.
- Runs or falls in the mines, 357, 375, 378.
- Rutty, Dr. natural history of Dublin, 366, 386.
- Sandyford in Wicklow, gossan near, 396.
- Sedgwick on joints in granite, 369.
- Schmölnitz, cupreous waters of, 385.
- Sicily, sulphur trade of, 390, 396.
- Silver-lead lode at Barristown, 399.
- Silver, native, at Ballycorus mine, 365.  
 —— extracted from gossan at Cronebane, 389.
- Slate district, mines of the, 374.  
 —— near the copper lodes, 372, 379, 380.  
 —— in the Glenmalure lode, 360.
- Stream-works, 400, 406.
- Sulphur ore of Ballymurtagh, 372.  
 —— Ballygahan, 376.  
 —— Tigroney and Cronebane, 378.  
 —— Connary, 384.  
 —— rise of the trade in, 390.  
 —— returns of the, from the Wicklow mines, 391.
- T's, or cross-veins, 373, 379.
- Tigroney and Cronebane, 378.
- Tin ore in Wicklow, 404.
- Transylvania, demoralization produced by gold streaming, 402.
- Veins of granite in Wicklow, 351 ; of mica, 352, 362.
- Weaver, his memoir on the east of Ireland, 349.  
 —— appointed Commissioner for gold stream works, 401.  
 —— his discovery of tin-stone in Wicklow, 405.
- Wexford, mines of, 397.









# LIST OF GEOLOGICAL MAPS AND SECTIONS OF THE GEOLOGICAL SURVEY OF THE UNITED KINGDOM,

PUBLISHED BY MESSRS. LONGMAN & CO. FOR HER MAJESTY'S STATIONERY OFFICE.

THE Maps are those of the Ordnance Survey, Geologically Coloured by the Geological Survey of Great Britain and Ireland, under the Superintendence of Sir HENRY DE LA BECHE, C.B., Director-General. The various Formations are traced and coloured in all their Subdivisions.

GREAT BRITAIN:—*The Counties of which the Geological Survey is completed, are—*

BRECKNOCKSHIRE, Sheets 36, 41, 42, 56 (NW & SW), 57 (NE & SE). Sheets, 2s. 6d.

CARDIGANSHIRE, 40, 41, 56 (NW & SW), 57, 58, 59 (SE), 60 (SW). Sheets, 1s. 17s.

CARMARTHENSHIRE, 37, 38, 40, 41, 42 (NW & SW), 56 (SW), 57 (SW & SE). 1s. 19s.

CARMARFEDD, 74 (NW), 75, 76, 77 (N), 78, 79 (NW & SW). Sheets, 1s. 18s.

CORNWALL, including Sheets 24, 25, 26, 29, 30, 31, 32, & 33. Sheets, 2s. 5s.

DEVONSHIRE, including Sheets 20, 21, 22, 23, 24, 25, 26, 27, & 29. Sheets, 2s. 11s.

\* \* \* The Geology of the Counties of CORNWALL and DEVON is amply illustrated by Sir H. De la Beche's "Report." 8vo. 1s.

17. [South West of Dorset.] 7s.  
18. [Northern half of Dorset, and South-eastern part of Somerset.] 12s.

19. [Half of Somerset, and part of West Wilts.] 11s. 6d.  
20. [West Somerset and part of South Glamorgan.] 5s. 6d.

21. [SW. Somerset, NE. Devon, and part of West Dorset.] 10s.

22. [Part of SE. Devon.] 7s.  
23. [Devon between Torbay and Start Point.] 3s.

24. [Part of South Devon and of Cornwall.] 3s. 6d.  
25. [SW. Devon and East Cornwall.] 10s.

26. [West Devon and NE. Cornwall.] 6s.  
27. [Devonian Rocks.] 3s. 6d.

28. [Lundy Island.] 2s. 6d.  
29. [The North of Cornwall, showing the Coast line from Hartland Quay to Cambbeck.] 2s. 6d.

30. [Part of Cornwall.] 7s. 6d.  
31. [Part of Cornwall.] 7s. 6d.

32. [Part of Cornwall.] 3s.  
33. [Part of Cornwall.] 5s.

35. [Western Gloucester, the SE. of Monmouth, part of North Somerset and West Wilts.] 10s.

36. [The greater part of Glamorgan on the West, and Monmouth on the East.] 13s.

37. [West Glamorgan and South Carmarthen.] 8s.  
38. [South Pembrokeshire.] 4s.

39. [Small's Light, Pembrokeshire.] 2s. 6d.

40. [North Pembrokeshire and West Carmarthen.] 8s.  
41. [Most of Carmarthen, parts of North Glamorgan, South Cardigan, and East Pembrokeshire.] 8s.

42. NW. [West Brecknock and part of East Carmarthen.] 2s.  
43. NE. [Part of East Brecknock and West Hereford.] 2s.

42. SW. [SW. of Brecknock, part of North Glamorgan and East Carmarthen.] 2s. 6d.

42. SE. [NE. of Glamorgan and Monmouth Coalfield.] 3s.

43. NW. [The Old Red Sandstone and part of the Silurian Strata of Woolhope.] 2s.

43. NE. [Silurian District of Woolhope, with the Malvern Country as far North as the Wych.] 2s. 6d.

43. SW. [The West of Dean Forest Coalfield.] 3s.

43. SE. [The greater part of Dean Forest Coalfield.] 3s.

54. NW. [Part of Worcestershire.] 2s.

55. NE. [Part of Shropshire and Worcestershire.] 3s. 4d.

55. NW. [Part of Hereford, Worcester, and Shropshire.] 2s.

55. SW. [Part of Hereford.] 2s. 6d.

55. SE. [Part of Hereford and Worcester.] 2s. 6d.

56. NW. [Part of Brecon, Cardigan, Radnor, and Montgomery.] 2s. 6d.

56. NE. [Part of Radnor, Montgomery and Shropshire.] 2s. 6d.

58. SW. [Part of Radnor, Brecon, and Carmarthen.] 3s.

58. SE. [Part of Radnor and Hereford.] 2s. 6d.

57. NW. [Part of Cardiganshire.] 1s.

57. NE. [Part of Cardiganshire.] 2s. 6d.

57. SW. [Part of Cardiganshire.] 1s. 6d.

GLAMORGANSHIRE, including Sheets 20, 36, 37, 41, & 42 (SE & SW). Sheets, 2s.

\* \* \* Horizontal Sections, 1s.; Vertical, 2s.; illustrate this County.

MERIONETHSHIRE, 59 (NE & SE), 60 (NW), 74 (NW, NE, & SW), 75 (NE & SE). 1s. 4s. 6d.

MONMOUTHSHIRE, including Sheets 35, 36, 42 (SE & NE), 43 (SW). Sheets, 1s. 11s.

\* \* \* Horizontal Sections, 7s.; Vertical, 5s.; illustrate this County.

MONTGOMERYSHIRE, 56 (NW), 59 (NE & SE), 60, 74 (SW & SE). 1s. 5s. 6d.

PEMBROKESHIRE, 36, 39, 40, 41, 58. 1s. 5s.

RADNOESHIRE, 42 (NW & NE), 56, 60 (SW & SE). 1s. 6s. 6d.

SOMERSETSHIRE, 18, 19, 20, 21, 27, 35. 2s. 12s. 6d.

57. SE. [Part of Cardiganshire, including Lampeter to Tre-garon.] 2s.

58. [Part of the Coast of Cardiganshire (Cardigan) and N. Pembrokeshire.] 2s. 6d.

59. NW. [Sea.]

59. NE. [Part of Cardigan, Montgomery, and Merioneth.] 3s.

59. SW. [Sea. (No Geological Colouring.)] 6d.

59. SE. [The North of Cardiganshire; part of the West of Montgomery and the South of Merionethshire.] 3s.

60. NW. [Part of Montgomery and Merioneth.] 2s. 6d.

60. NE. [Part of Montgomery and Shropshire.] 2s. 6d.

60. SW. [Part of Cardigan, Montgomery, and Shropshire.] 3s.

60. SE. [Part of Montgomery, Radnor, and Shropshire.] 3s.

61. NW. [Part of Shropshire.] 2s. 6d.

61. NE. [Part of Shropshire and Staffordshire.] 3s.

61. SW. [Part of Shropshire.] 3s.

61. SE. [Part of Shropshire.] 3s. 6d.

62. SW. [Part of Staffordshire, including the Coalfield.] 3s.

62. NW. [Part of Staffordshire, including the Coalfield.] 2s.

72. NE. [Part of North Staffordshire and of SW. Derbyshire.] 3s. 6d.

72. SW. [Central Part of Staffordshire.] 2s.

72. SE. [Part of Staffordshire and SW. Derbyshire.] 2s.

74. NW. [Part of Denbigh, Merioneth, and Caernarvon.] 3s.

74. NE. [Part of Denbigh, Flint, Shropshire, and Merioneth.] 3s.

74. SW. [Part of Montgomery, Denbigh, and Merioneth.] 3s.

74. SE. [Part of Shropshire, Montgomery, and Denbigh.] 3s.

75. NW. [Part of Caernarvon.] 2s.

75. NE. [Part of Caernarvon, Merioneth, and Denbigh.] 3s. 6d.

75. SW. [Part of Caernarvon.] 2s.

75. SE. [Part of Merioneth.] 3s. 6d.

76. N. [Part of Caernarvon.] 1s.

76. S. [Part of Caernarvon.] 1s. 6d.

77. N. [Part of Holyhead Island.] 1s. 6d.

78. NW. [N. part of Anglesea and part of Holyhead Island.] 4s.

78. NE. [E. corner of Anglesea.] 2s.

78. SW. [S. of Holyhead Island and of Anglesea, with part of Caernarvonshire.] 3s. 6d.

78. SE. [Part of Anglesea on Menai Straits, NE. of Caernarvonshire, and W. of Denbighshire.] 5s. 6d.

79. NW. [Part of Flint, Denbigh, and Caernarvon.] 2s. 6d.

79. NE. [Part of Flint, Cheshire, and Lancashire.] 2s.

79. SW. [Part of Flint, Caernarvon, and Denbighshire.] 2s. 6d.

79. SE. [Part of Cheshire, Flint, and Denbigh.] 3s. 6d.

81. NE. [Part of Derbyshire and of the West Riding of Yorkshire.] 3s. 6d.

81. SE. [Part of Derbyshire and of N. Staffordshire.] 4s. 6d.

82. NW. [Chesterfield, part of Derbyshire.] 2s. 6d.

82. SW. [Chesterfield, part of Derbyshire.] 3s. 6d.

## LIST OF THE PUBLICATIONS OF THE GEOLOGICAL SURVEY, ETC.—continued.

### HORIZONTAL SECTIONS,

#### *Illustrative of the Survey's Geological Maps.*

These Sections are drawn to a scale of six inches to a mile, horizontally and vertically, and describe in detail the Geology of the Country over which they are drawn. Descriptions are engraved on each plate, thus rendering each Section a concise Report on the district it traverses. The size of each plate is 3 ft. 3 in. by 2 ft. 3 in. They are engraved on Copper by Mr. Lowry, and coloured in accordance with the Maps. Sheets 1 to 21, 23 to 30 and 35 and 38, price 7s. each.

### VERTICAL SECTIONS,

#### *Illustrative of the Horizontal Sections and Maps of the Geological Survey.*

These Sections are arranged, in the form of Vertical Columns, to a scale of 40 ft. to an inch, and illustrate such details as it is impossible to give in the Horizontal Sections above described. In the Coal Measure Sections, for instance, the Thickness of each Bed of Coal, the Mineral Structure and Thickness of the Strata with which they are associated, and the kind and Amount of Ironstone, are given in the greatest detail. Sheets 1 to 18, price 5s. each Sheet.

### MAPS OF IRELAND.

INDEX MAP of CARLOW.	Geologically coloured, price 7s.
DO. KILDARE.	do. 7s.
DO. WICKLOW.	do. 7s.
DO. DUBLIN,	do. 7s.

INDEX MAP of WEXFORD.	Geologically coloured, price 7s.
Horizontal Sections to WICKLOW.	4 Sheets. 7s. each.

Plan and Sections of the OVOCa MINES. 7s.

### BOOKS Published under the Superintendence of the Geological Survey.

REPORT on CORNWALL, DEVON, and WEST SOMERSET. By Sir H. T. DE LA BECHE, F.R.S. &c. 8vo. 14s.

FIGURES and DESCRIPTIONS of the PALÆOZOIC FOSSILS in the above Counties. By PROFESSOR PHILLIPS. 8vo. 9s.

THE MEMOIRS of the GEOLOGICAL SURVEY of GREAT BRITAIN, and of the MUSEUM of ECONOMIC GEOLOGY of LONDON. 8vo. Vol. I. 21s.; Vol. II. (in 2 Parts), 42s.

BRITISH ORGANIC REMAINS. Forming a portion of the Memoirs of the Geological Survey. Decades I. II. III. IV. VI. and VII. with 10 Plates each. Royal 4to. 4s. 6d.: or royal 8vo. 2s. 6d. each Decade.—Other DECADES are in the Press.

RECORDS of the SCHOOL OF MINES and of SCIENCE applied to the ARTS. Vol. I. Part I. Inaugural and Introductory Lectures to the Courses for the Session 1851-52. Royal 8vo. price 1s. 6d. cloth. Vol. I. Part II. On the Geology of the South Staffordshire Coalfield. By J. BEEFE JUKES, M.A., F.R.S., &c. Price 2s. 6d. Vol. I. Part III. On the Mines of Wicklow and Wexford. By WARINGTON W. SMYTH, M.A., &c.

These Maps, Sections, and Books may be obtained at the Geological Survey Office,  
Museum of Practical Geology, Jermyn-street, London.







